U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY—BULLETIN NO. 47, PART II.

D. E. SALMON, D. V. M., Chief of Bureau.

THE HOG INDUSTRY.

SELECTION, FEEDING, AND MANAGEMENT.
RECENT AMERICAN EXPERIMENTAL WORK.
STATISTICS OF PRODUCTION AND TRADE.

BY

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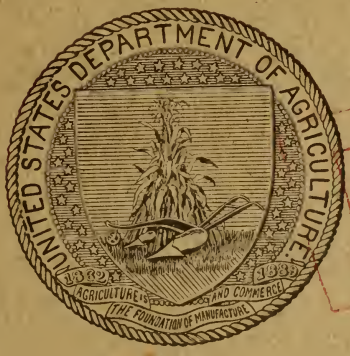

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CORN AND CORN SUBSTITUTES.

To the farmer of the corn belt those experiments with grains which may take the place of corn for feeding purposes in times of scarcity are always interesting. In seasons such as that of 1901, when a summer of extreme heat and little or no rain follows a spring of normal conditions, the short corn crop is frequently counterbalanced by a bountiful supply of small grains. Many farmers at such times rely on wheat, barley, oats, and rye to carry their stock to marketable condition. Outside the corn-growing districts such experiments are of even more importance, for the small grains are often grown in great abundance and form the basis of all rations.

Wheat compared with corn.—At the Indiana Station[a] Plumb and Anderson fed four lots of 4 Chester White pigs to study the relative value of feeding wheat and corn, both alone and in combination. The pigs were farrowed late in October, and the experiments began as soon as they were weaned, which was early in January. They were out of two sows that were litter sisters. Lot I received whole corn; Lot II received dry whole wheat; Lot III received a ration consisting of equal parts of corn and wheat; Lot IV received soaked whole wheat.

Up to March 6 they received 10 pounds of separator milk as a noon feed and after that date 12 pounds of the same daily. They were fed one hundred and five days. The results were as follows:

Wheat compared with corn for pigs.

Lot.	Ration.	Number of pigs.	Weight at beginning.	Weight at close.	Number of days fed.	Average daily gain.	Feed per 100 pounds gain.[a]
			Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
I	Corn	4	185	673	105	1.16	312
II	Wheat (dry)	4	175	607	105	1.02	355
III	Corn and wheat, equal parts	4	174	646	105	1.12	323
IV	Wheat (soaked)	4	189	633	105	1.05	355

[a] Digestible dry matter.

At the Utah Station, Foster and Merrill[b] conducted similar work in comparing ground wheat with corn meal. Two lots of 3 pigs each were fed, in covered pens, all the ground grain they would eat. The results follow:

Ground wheat compared with corn meal for pigs.

Ration.	Number of pigs.	Weight at beginning.	Weight at close.	Number of days fed.	Average daily gain.	Feed per 100 pounds gain.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
Corn meal	3	290	519	91	0.85	558
Ground wheat	3	291	615	91	1.20	464

[a] Bul. No. 67. [b] Bul. No. 70.

At the usual price of corn and wheat, 75 cents per hundredweight, the cost of gain for the corn-fed lot is given as $4.18 per 100 pounds, and that of the wheat-fed lot at $3.48 per 100 pounds.

At the close of this test a second one was made, but the ration of the first lot was made equal parts of corn meal and pea meal after the middle of the test. The results follow:

Ground wheat compared with corn and pea meals for pigs.

Ration.	Number of pigs.	Weight at beginning.	Weight at close.	Number of days fed.	Average daily gain.	Pounds feed per 100 pounds gain.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
Corn and pea meals	3	260	670	115	1.12	407
Ground wheat	3	257	587	115	.96	403

Wheat compared with various other grains.—At the Nebraska Station, Smith[a] fed eight lots of 6 pigs each to study the comparative feeding value of wheat, rye, and corn, both alone and in combination. Charcoal and lime were fed occasionally. Four pigs in each lot were of the bacon type—Tamworth and Yorkshire—and two were of the fat, or lard, type, or "block" type, as the author expresses it. Each lot had an 8 by 12 foot cement-floored pen in a closed shed, with an 8 by 16 foot yard adjoining. The ground feed was mixed into a thick slop after being weighed; the soaked wheat was weighed before being soaked. The first cost of the pigs was $4.50 per 100 pounds and they were sold on the farm at $5.52½ per 100 pounds. Corn and wheat were charged at 55 cents per bushel, rye at 50 cents per bushel, and shorts at $18 per ton. Grinding was charged at 8 cents per 100 pounds for wheat and rye and 6 cents per 100 pounds for corn. A statement of the results follows:

Wheat compared with other grains for pigs.

Ration	Number of pigs.	Average weight at beginning.	Average weight at close.	Total gain.	Number of days fed.	Average daily gain.	Total feed eaten.	Feed per 100 pounds gain.	Profit per lot.
		Lbs.	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*
Whole wheat, dry	6	110	167.0	342	91	0.63	2,178	637	5.72
Whole wheat, soaked 18 to 24 hours	6	110	174.0	385	91	.70	2,210	575	7.81
Ground wheat	6	108	177.0	414	91	.76	2,317	559	6.43
Ground wheat and corn, equal parts	6	111	178.0	401	91	.74	2,351	586	6.03
Ground wheat and rye, equal parts	6	107	170.7	383	91	.70	2,376	621	4.34
Ground wheat and shorts, equal parts	6	109	174.0	388	91	.71	2,375	612	5.65
Ground corn	6	110	174.5	387	91	.71	2,356	609	3.60
Ground rye	6	107	168.0	367	91	.67	2,290	624	4.55

[a] Bul. No. 75.

In this experiment ground wheat gave the greatest returns for the least amount of grain, but did not return so large a profit as whole soaked wheat, owing to the expense of grinding. The undesirability of feeding whole wheat dry seems to be indicated by these results. Ground wheat and corn gave considerably better returns than ground wheat and rye or ground wheat and shorts. Ground corn and rye alone do not appear to advantage.

These results show wheat to have a feeding value fully equal to that of corn, and are in line with the work that has been previously published on this subject. In the first Utah test, wheat showed a very much better and cheaper gain than corn, but when pea meal was added to the corn-meal ration, wheat did not have so great an advantage. The Nebraska results are specially favorable to wheat feeding.

Feeding frosted wheat.—Nine experiments with wheat that had been more or less damaged by frost were conducted at the Central Experimental Farm of Canada.[a] The grain was fed alone, ground, unground, and in combination with other grains and skim milk.

The following shows the results and conclusions from the experiments:

Frosted wheat for pigs.

Experiment.	Ration.	How prepared.	Number of pigs.	Average weight at beginning.	Average weight at close.	Average not gain.	Number of days fed.	Average daily gain.	Average amount feed eaten.	Feed per 100 pounds gain.
				Lbs.	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*
1	Wheat	Ground, soaked 12 hours.	4	185	275	90	77	1.17	479	530
2	do	Whole, soaked 42 hours.	4	186	273	86	77	1.11	570	659
3	Wheat, barley, and pease.	do	4	187	278	92	77	1.19	557	607
4	Wheat	Ground, soaked 12 hours.	5	61	165	104	120	.87	441	423
5	do	do	4	104	192	88	56	1.57	233	265
	Skim milk								1,011	1,251
6	Wheat	Ground, soaked 18 hours.	12	103	187	84	84	1.00	442	526
7	Wheat and barley	Ground, soaked 30 hours.	21	117	179	62	84	.73	326	445
	Carrots								53	85
8	Barley, wheat, rye, and bran.	Ground, soaked 12 hours.	36	54	108	54	105	.51	207	385
9	Barley, rye, wheat, and bran.	do	31	108	191	83	83	1.00	268	323
	Skim milk								250	300

[a] Bul. No. 33.

The fact that this wheat had been injured by frost does not seem to have had a serious effect on its feeding value. In the majority of instances the gains made were satisfactory, and those cases in which a large amount of grain was required for 100 pounds of gain were generally with hogs of considerable maturity and consequently expensive feeders.

Barley compared with corn.—The following results were obtained with barley alone in comparison with corn alone in South Dakota, Colorado, and Canada:

Barley compared with corn for pigs.

Ration.	Number of tests.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed per 100 pounds gain.		
							Corn.	Barley.	Milk.
Colorado:[a]			*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Whole corn	6		71			0.39	700		[c]110
Ground corn	5		60			.46	540		[c]110
Whole bald barley	8		88			.58		500	[c]130
Ground bald barley	5		67			.74		360	[c]80
Whole common barley	4		68			.49		540	[c]70
Ground common barley	4		47			.70		430	[c]110
South Dakota:[b]									
Corn meal	1	5	126	430	56	1.53	453		
Barley	2	9	112	803	56	1.59		457	
Ontario Agricultural College:[c]									
Corn						.70	547		
Barley						1.17		456	
Central Experimental Farm, Ottawa:[d]									
Whole corn	1	3	72	354	91	1.30	290		231
Ground corn	1	4	74	392	112	.87	416		
Whole barley	1	4	99	400	84	1.19		364	252
Ground barley	1	4	73	444	112	1.00		435	

[a] Bul. No. 40.
[b] Bul. No. 63.
[c] An. Rpts., 1899 and 1900.
[d] Bul. No. 33.
[e] Quarts.

This table does not present an accurate comparison between barley and corn, as skim milk enters into the results in five instances when barley was fed, as against only three instances where corn was fed, but the results command interest in showing that the value of barley for hog feeding compares very favorably with that of corn.

Barley compared with corn, in combinations.—The South Dakota Experiment Station and the Ontario Agricultural College have reported tests with barley in combination with such feeds as shorts and middlings.

[End of Part I.]

The following table shows the results:

Barley compared with corn, with shorts or middlings for pigs.

Ration.	Number of tests.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed per 100 pounds gain.	
							Corn.	Barley.
South Dakota: [a]			*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*
Corn and shorts equal parts	2	9	111	840	56	1.67	413	----------
Barley and shorts equal parts	4	17	115	1,561	56	1.64	----------	456
Ontario Agricultural College: [b]								
Corn and middlings	1	11	63	--------	--------	.79	480	----------
Do	1	12	----------	--------	140	.817	432	----------
Do	1	5	55	664	--------	.677	[c]424.55	----------
Barley and middlings	1	13	63	--------	--------	.80	----------	490
Do	1	12	----------	--------	140	.841	----------	450
Do	1	4	42	501	--------	.639	----------	[c]439.22

[a] Bul. No. 63. [b] An. Rpts., 1899 and 1900. [c] Dry matter.

These results are not so favorable to barley as those of the preceding table, but it can also be said, in the light of these figures, that barley is nearly if not quite equal to corn for feeding pigs, judging it solely from the standpoint of rate and economy of gain, and if we take into consideration its effect on the carcass, it far surpasses corn as a high-grade pig feed. An experiment with purebred hogs at the Ontario Agricultural College, which is not included in the foregoing table, compared barley and corn. Some middlings and skim milk were given, but during the last month the grains were fed alone. While receiving middlings and skim milk the pigs on corn made the most economical gains, but after the middlings and skim milk were withdrawn the pigs on barley made the most rapid and economical gains. The experience of this institution places barley at the head of the list of American bacon-producing feeds.

Ground wheat and barley compared with shelled corn.—At the Colorado Station Buffum and Griffith[a] fed two lots of pigs to compare the feeding value of home-grown Colorado grains with corn, which must be imported from States further east. The pigs used were rather ordinary grade Poland Chinas and Berkshires, about eight months old at the beginning of the experiment. One lot was fed shelled corn; the other, a mixture of equal parts of ground wheat and barley. The wheat and barley were grown on the college farm. "The wheat was the common Defiance variety and was grown in a field producing 34 bushels per acre. The barley was of the common hulled variety and was grown in a field that produced 25 bushels per acre."

The pigs were kept in pens of equal size, each pen with a yard

[a] Bul. No. 74.

adjoining. The pens were well bedded with straw. Water was given in abundance and occasionally coal and ashes. The following table shows the results:

Ground wheat and barley compared with shelled corn for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Average gain.	Number of days fed.	Average daily gain.	Average amount of feed eaten.		Feed per 100 pounds gain.		Cost per 100 pounds gain.	Profit at 7 cents per pound.
						Corn.	Wheat and barley.	Corn.	Wheat and barley.		
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dols.*	*Dols.*
Corn	4	95	71.25	101	0.70	383.50	.....	540	.....	7.00	0.95
Wheat and barley	4	94.5	120.25	104	1.16	.....	546.50	.....	450	4.50	3.90

This experiment shows a mixture of wheat and barley to be much more valuable than corn alone for pig feeding. It also speaks very well for the econony of pork production in those States where corn is not a staple crop. Buffum and Griffith state that it is a common practice in the neighborhood of Fort Collins for farmers to exchange barley or wheat for corn on even terms, and even when corn is high in price and wheat and barley cheaper, they will sell the cheaper home-grown grains and buy the expensive one. They give the average price for ten years of these grains in Colorado as 80.5 cents per 100 pounds for corn, 99.5 cents per 100 pounds for wheat, and 55.1 cents per 100 pounds for barley. They ask, very pertinently, whether Colorado feeders have not the solution of the problem of a supply of concentrates for pork production when home-grown grains sell on the farm for less money per 100 pounds than corn can be purchased in town, and especially when either wheat or barley is equal to corn for this purpose and in combination are superior to it.

Oats compared with corn.—Grisdale[a] reports a comparison of oats and corn. The grain was fed whole and was soaked fifty-four hours before feeding. Both lots received skim milk in addition. The results were as follows:

Oats compared with corn for pigs.

Pation.	Number of pigs.	Average weight at beginning.	Average weight at close.	Average gain.	Number of days fed.	Average daily gain.	Feed per 100 pounds gain.	
							Grain.	Milk.
		Pounds.	*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
Oats	4	97	170	73	84	0.87	421	345
Corn	3	72	190	118	91	1.30	200	231

[a] Bul. No. 33, Central Expt. Farm.

The results of this test are not very favorable to oats as a pig feed. To get even as economical a gain as could be had from corn a feeder would have to get nearly twice as good gains as from the oats; for, pound for pound of nutrient material, oats is about twice as expensive as corn.

Corn and Kafir corn.—The Oklahoma Station[a] compared Indian corn and Kafir corn as follows:

Six pigs, averaging about 135 pounds at the beginning of the test, were fed six weeks on Kafir heads, and made an average daily gain of 1.11 pounds, requiring about 665 pounds of grain for 100 pounds of gain.

Three pigs, averaging 220 pounds at the beginning, made an average daily gain of 1.53 pounds for thirty-five days, and required the equivalent of 494 pounds of shelled corn for 100 pounds of gain. These same pigs were then fed Kafir meal for two weeks and made 1 pound of gain per head daily, eating 921 pounds of meal for each 100 pounds of gain.

Four pigs, averaging 105 pounds, were fed thirty-five days on Kafir meal. They made an average daily gain of 1.21 pounds, eating 508 pounds of meal for 100 pounds of gain. For the next two weeks they were given soaked shelled corn. They made a total gain of only 30 pounds, eating 707 pounds of corn for 100 pounds of gain. For the next four weeks a daily supply of green alfalfa was given with good effect. A total gain of 140 pounds was made, requiring 365 pounds of grain for 100 pounds of gain.

Kafir corn.—The value of Kafir corn for hogs has been studied extensively at the Kansas Station. Kafir corn was found to have a feeding value considerably below that of corn when both grains were fed alone. In Bulletin No. 95, Cottrell states that the average of a number of trials shows that 527 pounds of Kafir corn and 468 pounds of Indian corn, respectively, are required per 100 pounds of pork made; the yield of pork per bushel of grain being 10.6 pounds in case of Kafir corn and 11.9 pounds with Indian corn. On upland soil, however, the average of eleven years on the Kansas Agricultural College farm shows returns of 46 bushels per acre for Kafir corn and 34½ bushels for Indian corn. Such returns, with gains as noted above, indicate a pork yield per acre of grain at 487 pounds for Kafir corn and 410 pounds for Indian corn. The great value of Kafir corn is its ability to resist drouth.

Soy beans in a Kafir corn ration.—In addition to the lighter returns from Kafir corn than from Indian corn, this grain is very constipating when fed alone, and hogs, especially young ones, tire of it sooner than they do of Indian corn. To remedy these difficulties a mixture

[a] An. Rpt., 1898–99.

is advised, especially with feeds of a laxative nature. One of the most convenient nitrogenous concentrates at the hands of the Kansas farmer is the soy bean. In a series of experiments[a] the effect of such an addition to both Indian corn and Kafir corn rations was studied. The following summary of five experiments shows that soy beans increase gains and diminish the amount of feed required for 100 pounds gain:

Effect of soy beans in a Kafir corn ration for pigs.

Ration.	Average gain.	Increased gain from soy beans.	Feed per 100 pounds gain.	Feed saved by feeding soy beans.
First experiment:	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*
Kafir corn meal	90.6		471	
Kafir corn meal ⅔ Soy bean meal ⅓	103.8	14.6	409	13.2
Second experiment:				
Kafir corn meal	102.0		559	
Kafir corn meal ⅔ Soy bean meal ⅓	145.7	42.8	408	27.0
Third experiment:				
Kafir corn meal	74.2		542	
Kafir corn meal ⅔ Soy bean meal ⅓	129.2	74.1	374	31.0
Corn meal	82.6		484	
Corn meal ⅔ Soy bean meal ⅓	120.4	45.5	369	23.7
Fourth experiment:				
Kafir corn meal	52.4		749	
Kafir corn meal ⅔ Soy bean meal ⅓	97.8	86.5	468	37.5
Fifth experiment:				
Kafir corn meal	44.1		653	
Kafir corn meal ⅔ Soy bean meal ⅓	86.6	96.4	435	33.2

The effect of feeding soy beans is good. Hogs receiving them "fatten rapidly, look thrifty, have strong appetites, and the hair and skin are glossy, like those of animals fed oil meal."

The following summary gives a more elaborate comparison of the relative values of Kafir corn or Indian corn meal alone and in combination with soy beans.[a] The results are arranged in order of economy of gains, the total showing the number of pounds of feed required for 100 pounds of gain.

[a] Bul. No. 95, Kansas Expt. Sta.

Value of soy beans in a Kafir corn or Indian corn ration.

Ration.	Feed per 100 pounds gain.	Ration.	Feed per 100 pounds gain.
	Pounds.		*Pounds.*
Corn meal ⅞, soy bean meal ⅛	369	Kafir corn meal, soaked forty-eight hours	542
Kafir corn meal ⅞, soy bean meal ⅛	374	Kafir corn, whole, soaked forty-eight hours	550
Kafir corn meal ⅞, soy bean meal ⅛	408	Kafir corn meal, wet	559
Kafir corn meal ⅞, soy bean meal ⅛	409	Kafir corn, whole, soaked forty-eight hours	632
Kafir corn meal ⅞, soy bean meal ⅛	435	Kafir corn, whole, wet	638
Kafir corn meal ½, corn meal ½	456	Kafir corn, whole, wet	640
Shelled corn, dry	457	Kafir corn meal, wet	653
Kafir corn meal ⅞, soy bean meal ⅛	468	Kafir corn, whole, dry	655
Kafir corn meal, wet	471	Kafir corn meal, wet	691
Kafir corn meal ½, corn meal ½, wet	477	Kafir corn meal, dry	749
Shelled corn, dry	479	Average	528
Corn meal, soaked forty-eight hours	484		
Kafir corn, whole, dry	512		
Kafir corn meal and cotton-seed meal	540		
Kafir corn, whole, dry	542		

"The six lots of hogs having soy beans as part of their ration required an average of 411 pounds of grain for 100 pounds of gain, while the 19 lots not fed soy beans required an average of 564 pounds of feed for 100 pounds of gain, an increase in food required of over 37 per cent."

Pease compared with wheat.—The Utah Station[a] compared the values of pease and wheat during two years. The pigs were confined in yards and the grain was given whole and dry. The average of results was as follows:

Pease compared with wheat for pigs.

Ration.	Total weight at beginning.	Total gain.	Feed per 100 pounds gain.
	Pounds.	*Pounds.*	*Pounds.*
Pease	147	303	452
Wheat	136	282	476

Cowpeas alone compared with corn alone.—At the South Carolina Station[b] Newman and Pickett fed to compare cowpeas with corn. The pigs were from eight to eleven months old and were fed in pens. There were 3 pigs in each lot.

The cowpea-fed lot ate 6.7 pounds of cowpeas per head daily and made an average daily gain for the lot of 3.38 pounds. They required 491 pounds of cowpeas to produce 100 pounds of gain.

The corn-fed lot ate 9.2 pounds of corn per head daily and made an average daily gain for the lot of 4.17 pounds. They required 602 pounds of corn to produce 100 pounds of gain.

With pork at 5 cents per pound and corn and cowpeas yielding 15 bushels and 10 bushels, respectively, per acre, the value of an acre of corn in this experiment was $6.97 and that of an acre of cowpeas $6.12.

[a] Bul. No. 70. [b] Bul. No. 52.

Ground cowpeas and corn meal compared with corn meal.—At the Alabama Station[a] Duggar fed two lots of pigs to compare the relative value of a ration of half corn meal and half ground pease with an exclusive corn-meal ration. The pigs used were placed in covered pens, with small yards adjoining, and, after a preliminary period of a week, put into the experiment which lasted sixty days. The results are as follows:

Ground cowpeas and corn meal compared with corn meal for pigs.

Ration.	Gain.	Number of days fed.	Feed eaten.	Feed per 100 pounds gain.
	Pounds.		*Pounds.*	*Pounds.*
Ground corn alone	68	60	548	806
Corn ½, cowpeas ½	108	60	570	528

In this experiment the cowpea and corn-meal ration made gains 34 per cent more economical than corn alone. The quality of the pork made was as good as that of corn-fed pork.

Peanuts compared with corn meal.—Duggar[a] placed in pens the pigs used to compare the values of peanut pasture and corn meal (see p. 160) to make a more accurate study of the nutritive values of Spanish peanuts and corn meal. The lots received the same rations, except that the peanuts were dry and fed unhulled. The test lasted six weeks with the following results:

Peanuts compared with corn meal for pigs.

Ration.	Number of pigs.	Number of days fed.	Total gain.	Average daily gain.	Feed per 100 pounds gain.
			Pounds.	*Pound.*	*Pounds.*
Peanuts ½, corn meal ½	3	42	84	0.67	370
Peanuts only	3	42	59.5	.47	280
Corn meal only	2	42	8.6	.10	1,070

This experiment shows the best daily gains from the combination of peanuts and corn meal, and shows the best returns for feed eaten by the pigs on peanuts alone. This lot made very much better gains than the pigs fed exclusively on corn meal, which fed very poorly. The pigs on peanuts alone made a gain of 9 pounds per bushel of peanuts. "This gives a value of 27 cents to a bushel of Spanish peanuts when pork is worth 3 cents per pound gross, and 31½ cents when pork is worth 3½ cents per pound." The unthrifty appearance of the pigs fed on corn meal only was commented upon.

At the South Carolina Station, Newman and Pickett[b] fed two lots of grade Berkshire and Duroc Jersey pigs, from eight to eleven months old, in pens, to study the relative values of peanuts and corn. On land of similar character they estimated the corn yield at 15 bushels per acre and peanuts 90 bushels, and in their investigations they found that,

[a] Bul. No. 93. [b] Bul. No. 52.

with exclusive corn feeding, 602 pounds of corn were required for 100 pounds of gain and with peanuts 443 pounds for 100 pounds of gain. On this basis, an acre of corn will produce 140 pounds of pork and an acre of peanuts 488 pounds, worth, respectively, when pork is 5 cents per pound, $6.97 and $24.37.

COMMERCIAL BY-PRODUCTS.

One of the prominent features of modern industry is the development of the possibilities of the by-product—the waste and offal of manufacturing establishments. Farmers have long appreciated the value of the by-products of flour mills, but of recent years many other materials have come into the market as valuable feed for farm animals. Rice mills, oil mills, and packing houses all have their by-products, which are useful in supplementing the products of the farm.

MILLING PRODUCTS.

The by-products of the flour mills have for years been bought by farmers for use in the feed box, and one of these—middlings—has come to have an unsurpassed reputation for hog feeding, especially for young animals in the early stages of fattening. With the development of milling the ingenuity of the manufacturer has enabled him to throw a host of new foods upon the market. In consequence, we have, in the first place, a by-product more completely deprived of its nutrient material, perhaps, than formerly, but more uniform in quality; and, in the second place, a greater variety of feeds with which to supply the bins. It is not alone the products of the flour mills that have value for feeding purposes. The rice mills, glucose factories, and oil mills all have by-products that are useful adjuncts to feeding operations. Indeed, most of the experimental work of recent years deals with the value of the by-products of these industries. In the majority of instances these feeding stuffs are best used as adjuncts to corn or corn meal, although often the proximity of feed yards to a mill cheapens the by-products sufficiently to enable the feeder to use them as the main part of the ration.

Bran and corn meal compared with corn meal.—Burkett[a] fed two lots of 3 pigs each, one receiving a ration of equal parts of bran and corn meal and milk and the other corn meal and milk. The object was to compare the value of bran in such a ration and have the corn-fed lot as a check. The results follow:

Bran and corn meal compared with corn meal for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed per 100 pounds gain.	
						Grain.	Milk.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Bran and corn meal	3	47.6	227	99	0.76	308	882
Corn meal	3	47	323	99	1.08	263	663

[a] Bul. No. 66, New Hampshire Expt. Sta.

This experiment gave much better returns for a corn-meal and skim milk ration than for one where bran was added. Burkett does not value bran highly as a pig feed either alone or in combination with corn meal.

Shorts compared with corn.—At the Colorado Station, Buffum and Griffith[a] fed purebred Berkshire pigs about 5 months old to compare the feeding value of corn meal and shorts in combination with wheat, barley, and oats. One lot received shorts, wheat, oats, and barley in rotation—shorts with wheat and oats one day, with wheat and barley the next, with oats and barley the next, and so on. The lot on corn had the same method of feeding and the same ration, except that corn was fed in place of shorts. Feed was charged at the following prices: Corn, 83 cents per 100 pounds; shorts, 75 cents per 100 pounds; wheat, 95 cents per 100 pounds; oats, $1.20 per 100 barley, $1.20 per 100 pounds. The experiment lasted from March 23 to May 31, 1901—sixty-nine days—the results being as follows:

Shorts compared with corn in mixed rations for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Average gain.	Number of days fed.	Average daily gain.	Average amount feed eaten.			Feed per 100 pounds gain.	Cost per 100 pounds gain.
						Corn.	Shorts.	Other grain.		
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	
Shorts and grain	3	112.5	88.2	69	1.31	.....	226.5	225.6	521	$4.70
Corn and other grain	3	98	85.6	69	1.27	208.6	.....	209.1	487	4.70

At the Indiana Station Plumb and Anderson[b] fed two lots of 3 high-grade Chester White gilts, each five and one-half months old, to compare the value of a ration of corn meal and wheat shorts with a ration of corn meal only. The mixture was equal parts by weight of corn meal and shorts. The pigs were fed in pens with small shelter houses attached. Shorts were valued at $14 per ton and corn meal at $13.50 per ton. The results were as follows:

Feeding value of wheat shorts.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Total feed eaten.		Feed per 100 pounds gain.	Cost of feed per 100 pounds gain.
						Shorts.	Corn meal.		
		Pounds.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Pounds.*	*Dollars.*
Shorts and corn meal	3	129	354	70	1.69	718	718	406	2.74
Corn meal	3	129	327	70	1.56	.....	1,413	432	2.80

The mixture of corn meal and shorts gave larger, more rapid, and more economical gains than a ration of corn meal only. In the Colo-

[a] Bul. No. 74. [b] Bul. No. 71.

rado experiments the pigs fed on a ration of shorts made larger and more rapid gains than those on corn meal, but they required more feed per 100 pounds gain.

Corn meal compared with rice meal.—The South Carolina Station[a] compared rice meal and corn meal. "The rice meal is a by-product of the rice mills and consists largely of rice flour, rice polish, and rice bran. As yet the mills have no uniform way of putting it on the market, and, in order that the reader may understand what is meant by rice meal, as used in this experiment, it may be said that it is all the by-product obtained in cleaning the rice grain for the market. Its chemical composition shows that it has about the same amount of protein, carbohydrates, and fat as corn meal."

The pigs used were Berkshires, about five months old, weighing about 90 pounds each. They were given a ration consisting of 1 part meal and 4 parts skim milk, the milk being mixed with the meal, and were confined in pens 20 by 40 feet, with plenty of shade.

The experiment was divided into two periods. During the first period of thirty-nine days Lot I was fed the corn-meal ration and Lot II the rice-meal ration; during the second period of twenty-two days the feed was reversed, Lot I having rice meal and Lot II corn meal.

The results during the first period were not decisive, but during the second they were somewhat favorable to the rice meal.

The results for each kind of grain for the entire experiment are as follows:

Rice meal compared with corn meal for pigs.

Ration.	Number of pigs.	Total gain.	Number of days fed.	Average daily gain.	Feed eaten.		Feed per 100 pounds gain.		Cost of feed per 100 pounds gain.
					Meal.	Milk.	Meal.	Milk.	
		Lbs.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dollars.*
Rice meal 1 part, skim milk 4 parts	3	314.5	61	1.72	779	3,116	248	991	3.84
Corn meal 1 part, skim milk 4 parts	3	303	61	1.66	779	3,116	257	1,028	4.63

The corn meal was valued at $20 per ton, rice meal at $15 per ton, and skim milk at 20 cents per 100 pounds. This experiment shows that rice meal, such as was used in this test, is fully as valuable as corn meal in pig feeding and corroborates previous work along this line.

Feeding value of rice polish.—Owing to the high price of corn during 1902, Duggar[b] devoted considerable attention to the investigation of the value of those feeds whose composition seemed to indicate that

[a] Bul. No. 55. [b] Bul. No. 122, Alabama Expt. Sta.

they could be used as substitutes for corn meal in pig feeding. In this connection rice polish was fed to a number of pigs under different conditions. Rice polish is a by-product of the rice mills and is difficult to obtain in some sections of the country, as millers often mix it with less valuable by-products and sell the mixture under the name of "rice meal." For this reason rice meal is said to be a variable and uncertain quantity and all samples do not have equal feeding value. In 1902 rice polish was quoted by a Savannah mill at $17.90 per ton, delivered at Auburn, Ala., in less than carload lots. Two years before the same firm had been paid $26 per ton for it delivered at Auburn. It is stated that some of it kept in good condition for more than a year.

Duggar reports seven tests with this by-product. He compared it with corn meal with and without the addition of skim milk, and in a mixed ration of cowpea meal and wheat bran; with a ration of one-half cowpea meal, one-fourth corn meal, and one-fourth rice bran, with the addition of skim milk; and in different proportions with other feeds without skim milk. The pigs used were generally recently weaned and the meal was fed dry.

The following table summarizes the results:

Feeding value of rice polish.

Ration.	Number of pigs.	Total gain.	Number of days fed.	Average daily gain.	Feed per 100 pounds gain.		
					Grain.		Milk.
					Rice polish lots.	Other lots.	
		Lbs.		*Pounds.*	*Pounds.*	*Lbs.*	*Lbs.*
Corn meal and skim milk	3	90	35	0.86	.....	210	465
Rice polish and skim milk	3	109	35	1.04	170	.....	367
Corn meal	3	.....	.....	.....	.....	670	.....
Rice polish	3	.....	.....	.....	670	.....	.....
Corn meal	3	54	28	.64	.....	501	.....
Rice polish	3	79	28	.94	340	.....	.....
Corn meal	3	68	56	.40	.....	621	.....
Rice polish	3	132	56	.79	375	.....	.....
Corn meal 2, cowpea meal 2, wheat bran 1	3	56	28	.67	.....	370	.....
Rice polish 2, cowpea meal 2, wheat bran 1	3	66	28	.79	310	.....	.....
Cowpea meal 2, corn meal 1, rice polish 1, and skim milk	3	.....	35	.....	.....	178	413
Rice polish and skim milk	3	.....	35	.....	193	.....	474
Cowpea meal 2, corn meal 1, rice polish 1	3	.....	35	.....	.....	500	.....
Corn meal 1, rice polish 1	3	.....	35	.....	420	.....	.....

In every instance where data were furnished, the pigs on rice polish show more rapid gains than those on corn meal or mixed grain rations. In only two cases did rice polish fail to prove more economical. One of these was the second test with corn meal, where 670 pounds of feed were required by the pigs on both rations. The other was a test with

a mixed ration, where 2 parts cowpea meal, 1 part corn meal, and 1 part rice polish, with skim milk, gave gains at an outlay of 178 pounds grain and 413 pounds skim milk, as compared with 193 pounds grain and 474 pounds skim milk by the ration of rice polish and skim milk.

Duggar summarized the results where rice polish and corn meal were compared directly, and found that an average of 373 pounds of rice polish were required to produce 100 pounds gain, as compared with 474 pounds of corn meal. "At this rate, 78.6 pounds of rice polish were equal to 100 pounds of corn meal, a saving of 21.4 per cent of the grain by the substitution of polish for corn meal."

Gluten meal compared with corn meal.—Pigs that had been fed without success on a potato ration at the Cornell Station[a] were given a "rational ration" of corn meal and skim milk for a week and then they were employed in a test to compare gluten and corn meal. Skim milk was fed, the proportion to meal being about 3 pounds of milk to 1 of meal. Lots I and III received gluten meal and milk, and Lots II and IV corn meal and milk.

Gluten meal was charged at $11.75 per ton, corn meal at $14 per ton, and skim milk at 15 cents per 100 pounds.

The following were the principal results:

Gluten meal compared with corn meal for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Dry matter per 100 pounds gain.	Cost per 100 pounds gain.	Dressed weight.	Nutritive ratio.
		Pounds.	*Pounds*		*Pounds.*	*Pounds.*	*Dollars.*	*Per cent.*	
Gluten meal and milk	4	87.25	214	50	1.07	319	2.70	77.40	1:2.7
Corn meal and milk	4	90.5	297.5	50	1.49	264	2.50	80.20	1:5.8
Gluten meal and milk	4	47.5	157.5	50	.79	252	2.40	----------	1:2.7
Corn meal and milk	4	48.5	219	50	1.10	151	1.90	----------	1:5.8

The use of gluten meal in combination with skim milk in this experiment did not give results so satisfactory as where corn meal and milk were fed. Both corn meal lots made better gains and the average of dry matter consumed, and cost per 100 pounds gain were much lower than with the pigs on gluten meal and milk.

Hominy meal compared with corn meal.—In Massachusetts the Hatch Station[b] compared hominy meal and corn meal. The latter is described as consisting of "the hulls, germs, and some of the starch and gluten of the corn ground together. This separation is said to be brought about solely by the aid of machinery. The hard flint part of the corn is the hominy, which is used as a human food."

Seven Chester White grades were fed on a grain and skim-milk ration, 7 to 10 quarts of skim milk being fed daily with a grain allow-

[a] Bul. No. 199. Cornell Univ. Expt. Sta.

[b] Eleventh An. Rpt., Hatch Expt. Sta.

ance of 3 to 6 ounces to each quart of milk, depending on appetite and size. One lot received corn meal and milk, and the other hominy meal and milk. The results are shown in the following table:

Hominy meal compared with corn meal for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Total feed eaten.		Feed per 100 pounds gain.		Dry matter per 100 pounds gain.
						Grain.	Milk.	Grain.	Milk	
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Corn meal	4	56	503	98	1.28	1,022	7,702	203	1,532	321
Hominy meal	3	58	410	98	1.39	766	5,779	187	1,410	306

These figures show hominy meal, as fed in this experiment, to have a feeding value equal to that of corn meal. In this one test corn meal failed to give quite so good results as the hominy meal, showing an average daily gain of 1.28 pounds to 1.39 pounds for hominy meal, and 320 pounds dry matter for 100 pounds gain to 306 pounds dry matter for 100 pounds gain in the case of the hominy meal.

Corn meal compared with cerealine feed.—Two tests were made at the Hatch Station[a] to compare corn meal and cerealine feed. Like hominy meal, cerealine feed "consists also of the hull and a portion of the starch of the corn. It contains rather less of the starch than the hominy meal. It is the by-product resulting from the preparation of the breakfast food known as cerealine flakes. It is very coarse looking and appears very much like unground corn hulls."

In the first test 6 grade Chester White pigs about five weeks old were used. They were fed 6 to 9 quarts of skim milk per head daily, and the grain fed at the start was 3 ounces for each quart of milk; the grain was increased with age and weight. The nutritive ration was 1:3 at the beginning and 1:7 at the close.

In the second test 6 pigs, "a cross between the Poland China and the Chester White," about five weeks old, were fed. Skim milk was fed in connection with the cerealine feed, which was "eaten with seeming relish at all times." The following table shows the results:

Cerealine feed compared with corn meal for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Total feed eaten.		Feed per 100 pounds gain.		Dry matter per 100 pounds gain.
						Grain.	Milk.	Grain.	Milk.	
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Corn meal	3	48	413	106	1.30	731	4,827	177	1,169	260
Cerealine feed	3	45	398	106	1.25	731	4,827	184	1,212	277
Corn meal	3	68	315	78	1.34	680	3,061	216	972	281
Cerealine feed	3	67	293	78	1.25	676	3,061	231	1,041	305

[a] Eleventh An. Rpt., Hatch Expt. Sta.

In these tests cerealine feed showed considerable value as a pig feed, but failed to give as good results, either in rate or economy of gain, as corn meal. Digestion experiments at the Hatch Station with sheep have shown that cerealine feed contains as much digestible matter as corn meal. The station authorities suggest that the coarse nature of cerealine feed lessens its value as a pig feed.

Value of corn hearts.—Duggar[a] fed three lots of 3 pigs each to compare corn hearts with corn meal and cowpea meal. These feeds constituted half the ration, the other half being rice bran. The following table shows the results:

Value of corn hearts.

Ration.	Number of pigs.	Total gain.	Number of days fed.	Average daily gain.	Feed eaten.	Feed per 100 pounds gain.
		Pounds.		*Pounds.*	*Pounds.*	*Pounds.*
Corn hearts 1 Rice bran 1	3	65	35	0.62	480	738
Cowpea meal 1 Rice bran 1	3	81	35	.77	479	595
Corn meal 1 Rice bran 1	3	98	35	.93	540	550

Analyses at the Alabama Station indicated that the corn hearts used in this experiment contained 8.9 per cent protein and the rice bran 9 per cent protein.

Gluten meal compared with linseed meal for balancing rations.—Patterson, at the Maryland Experiment Station,[b] fed four lots of 5 high-grade Poland China pigs each to compare gluten meal and linseed meal as the nitrogenous components of a ration. Lots I and II received hominy chop three-fifths, linseed meal two-fifths; Lots III and IV received hominy chop three-fifths, King gluten meal two-fifths. Both lots had skim milk in the proportion of 1 pound of milk to 1 of grain. The results were as follows:

Gluten meal compared with linseed meal in a carbonaceous ration.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed per 100 pounds gain.		Cost per 100 pounds gain.
						Grain.	Milk.	
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*	*Dollars.*
Hominy chop ⅗, linseed meal ⅖	5	37	298	60	0.99	242	242	2.71
Hominy chop ⅗, linseed meal ⅖	5	36	294	60	.98	242	242	2.70
Average						242	242	2.70
Hominy chop ⅗, gluten meal ⅖	5	36	241	60	.80	233	233	2.20
Hominy chop ⅗, gluten meal ⅖	5	37	256	60	.85	220	220	2.07
Average						226	226	2.13

[a] Bul. No. 122, Alabama Expt. Sta. [b] Bul. No. 63.

This table shows advantages in favor of gluten meal. Both rate and economy of gain favor the corn by-product. The cost of the gluten-meal ration was much less than the one into which linseed meal entered.

COTTON-SEED MEAL.

No feed of the South has so wide a range of interest as cotton-seed meal. It is a concentrated feed of high value for cattle and sheep, and its effect on the fertilizing value of the manure is nearly as great as its effect on the feeding value of the ration.

The influence of cotton-seed meal extends far beyond the States where it is produced, and farmers over the entire country have come to depend upon it to balance their rations and enrich their fields.

Danger of use of cotton-seed meal in pig feeding.—For some reason as yet unexplained this by-product is usually fatal to pigs in from three to ten weeks after feeding has commenced, the mortality being at least 50 per cent. In two tests conducted by the Texas Experiment Station[a] boiled cotton seed gave the least serious results, while soaked raw seed, roasted seed, and raw meal proved more serious. In one test, 10 of the lot of 15 pigs fed cotton seed or cotton-seed meal died. At the Iowa Experiment Station,[b] of 6 pigs that were on a ration of cotton-seed meal, corn-and-cob meal, and buttermilk, 3 died. At the Kansas Experiment Station,[c] 4 young pigs on a ration composed of one-sixth cotton-seed meal and five-sixths corn meal died within forty-six days after feeding commenced. At the Arkansas Station,[d] three lots of 3 pigs each were fed mixed rations, the cotton-seed meal constituting one-third of the grain. All died.

The time intervening between the beginning of feeding cotton seed or cotton-seed meal and the first appearance of trouble varies somewhat. Curtis[e] gives six to eight weeks; Lloyd,[f] in one test, lost the first pig at the end of the fourth week; in another test, deaths began after forty days; Curtiss[g] lost the first pig fifty-one days after feeding commenced. Dinwiddie's[h] first pig died thirty-five days after feeding commenced, and Duggar[i] lost the first pig thirty days after feeding commenced. It therefore appears that there is no very definite period of time that is required for the poison to manifest itself. However, Cottrell[j] states that cotton-seed meal may be fed for three to four weeks before danger is imminent, and Burtis and Malone[k] state that no case has come under their experience "where a pig has died if the cotton-seed meal mixture has not been continued longer than three weeks."

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[a] Bul. No. 21.
[b] Bul. No. 28.
[c] Bul. No. 53.
[d] Bul. No. 76.
[e] Bul. No. 21, Texas Expt. Sta.
[f] Bul. No. 60, Mississippi Expt. Sta.
[g] Bul. No. 28, Iowa Expt. Sta.
[h] Bul. No. 76, Arkansas Expt. Sta.
[i] Bul. No. 122, Alabama Expt. Sta.
[j] Bul. No. 95, Kansas Expt. Sta.
[k] An. Rpt. 1901–02, Oklahoma Expt. Sta.

Symptoms of poisoning.—Poisoning is manifested in a peculiar manner. In many cases pigs that are apparently well in the evening are found dead in the morning, and often the most careful watching fails to show any indications of indisposition. Where symptoms are present those most characteristic seem to be disorder of respiration, which is manifested by quickened breathing, coughing, or hiccough. Failing appetite usually calls the attention of the feeder to the approach of danger. Seldom more than two days intervene between the first symptom and death. Francis[a] gives the following symptoms of the trouble with the Texas pigs:

> The attack was sudden, as a rule; in fact, in a majority of cases an animal was found dead that had been apparently well twelve hours before. In those cases which we were fortunate enough to witness the symptoms were those of a sudden contraction of the diaphragm, producing a sound similar to hiccough in man. The animal stood with head near the ground, the flanks tucked up, the ears hanging pendulous, and the tail straight and limp. Some would lie flat on the belly—never on the side—while others would assume a sitting-up posture with the fore legs well apart. In several cases there was a marked elevation of temperature, the thermometer registering 106° F. per rectum. The circulation seemed very weak and rapid. * * * As a rule they were dead in an hour. * * * The gaspings became more and more frequent and violent, and after a few struggles the animal was dead. In the last moments great quantities of foam or froth would come from the nose or mouth.

The symptoms observed by Dinwiddie[b] are described as follows:

> The disease in all cases was of a type which might be described as acute. In several instances the animals were said to be "off feed" for one or two days before other symptoms were observed. Every animal which exhibited any symptoms at all died within twenty-four hours. It would remain by itself, standing, disinclined to move, breathing with extreme rapidity and jerking or "thumping" in the flanks, and before death frothing at the mouth and nostrils. Fever was absent or but slight; eyes dull and sometimes bloodshot. Coughing occasionally occurred.

Pathological features.—Francis[a] states: "On postmortem examination the digestive organs appeared normal throughout. The other abdominal organs appeared normal. The respiratory organs were full of foam. The lungs themselves were bright red and very much congested and doughy." Mayo[c] pronounced the death of the Kansas pigs to be due in all cases to "congestion and inflammation of the intestines, lungs, and heart;" but Niles[d] could find no assignable cause of death in the case of the Iowa pigs.

Dinwiddie,[b] in the Arkansas experiments, made postmortem examinations of 8 of the 9 pigs which died, and found a very constant condition of disorder. He says, in describing the first examination, the description of which applied to all cases:

> The body presented no external changes. Subcutaneous tissue showed blood extravasations in streaks and points. Blood engorgement of lymph nodes of neck

[a] Bul. No. 21, Texas Expt. Sta.
[b] Bul. No. 76, Arkansas Expt. Sta.
[c] Bul. No. 53, Kansas Expt. Sta.
[d] Bul. No. 28, Iowa Expt. Sta.

and jaws. Respiratory and buccal mucous membrane dusky red. Pleural cavities contain a large quantity of yellow, cloudy fluid, compressing the lungs to less than half their normal bulk. In the pericardial sac there is a similar dropsical effusion, part of which has formed into a soft, yellowish-white clot. No evident pleuritis. Lung dark red, congested, and collapsed. Cavities of heart contain dark, soft blood clots; slight petechial extravasations on the epicardium. No obvious peritoneal effusion. Liver is dark in color, friable, and deeply blood-engorged, the lobular boundaries on section being unusually prominent, with dark-red depressed centers. Kidneys on section appear congested throughout, capsule nonadherent. * * *

The stomach and intestines often showed abnormal features. The small intestine (jejunum) frequently showed hyperemic patches on both the serous and mucous surfaces, and the large intestine and stomach in several cases contained considerable quantities of gravel. The urine was slightly albuminous in two cases. In one instance, where the brain was dissected, there was engorgement of the veins and sinuses of the dura mater, which extended "backward into the vessels of the neck."

The histological examination is described as follows:

Sections of the liver tissue reveal an intense congestion of the portal system, the intralobular capillaries especially being enormously engorged throughout and the liver cells compressed and shrunken. There is, however, no marked degeneration, and the nuclei take the stain in the normal manner. Sections of the kidney exhibit a similar capillary engorgement, though less intense. The glomerular tufts are compressed by edematous effusion into their capsules. A degenerative process in the cells of the urinary tubules or other marked pathologic changes were not demonstrated. In the spleen no distinct pathologic changes are found. Lung sections show a marked congestion of the capillary vessels, with edematous effusion and occasional blood extravasations, but without cellular proliferation or infiltration. There is no evidence of pneumonia or pleurisy.

Treatment.—As a rule, hogs suffering from the effects of cotton-seed poisoning, if taken from the cotton-seed ration and placed on rich green pasture, become apparently well in a week.[a] A similar result follows when they are simply deprived of the cotton-seed meal of the ration and given an ordinary grain ration. However, Burtis[b] reports a case where a pig died during the winter after a week's feeding on a straight corn diet that followed four weeks' feeding on a ration of one-fifth cotton-seed meal and four-fifths corn meal; and Dinwiddie and Duggar had similar experiences. In some cases pigs may pass through a season of cotton-seed meal feeding and thereafter be indifferent to it. Curtis[c] found that if a pig lived thirty days after the first appearance of trouble it could be regarded as immune from the effects of cotton seed, but the experience of others seems to contradict this. Dinwiddie[d] gives two months as the time

[a] Bul. No. 60, Mississippi Expt. Sta.: An. Rpts., 1900–01 and 1901–02, Oklahoma Expt. Sta.

[b] An. Rpt. 1901–02, Oklahoma Expt. Sta.

[c] Bul. No. 21, Texas Expt. Sta [d] Bul. No. 76, Arkansas Expt. Sta.

required for a hog to be on cotton-seed meal before it can be regarded as immune.

The cause of poisoning not known.—The poisonous agent of cotton seed has not yet been determined. So far chemical and bacteriological examinations have revealed nothing to which can be attributed its dangerous character. The injurious action has been variously attributed to the lint on the seed, the large fat content, the highly nitrogenous composition, the sharpness of the hulls, the presence of a toxin, supposititious chemical or bacteriological changes in the meal, formation of poisonous crystals by metabolism, etc. Up to a certain period the amount of cotton seed or cotton-seed meal fed does not seem to have any influence on the health of the pigs, but the evidence on the subject is so meager that one is not justified in drawing conclusions as to the amount of meal that can be fed safely. Curtiss[a] inclines to the toxin theory; he found the amount which proved fatal in his investigation to be from 27 to 33 pounds of cotton-seed meal. Dinwiddie[b] holds that the belief that there is a toxic principle in the seeds of the cotton plant is the most reasonable one, and one that has not been disproved. The action seems to be more virulent with young than with older animals, which is characteristic of poisons. He points out that the amount fed to pigs is much larger in proportion to their body weight than that fed to cattle and suggests this as a reason for the supposed greater immunity of cattle. With a 1,000 pound steer, 4 pounds of cotton-seed meal is an amount equal to 0.4 per cent of the body weight. In the case of the pigs in the Arkansas experiments the proportion was about 1.5 per cent of the body weight at the beginning of feeding. The amount of cotton-seed meal eaten per head was 23, 25, and 45 pounds, respectively, in the three experiments at that station. Dinwiddie[c] calls attention to the fact that other animals are susceptible to cotton-seed poisoning and states that guinea pigs, to which he fed small quantities of cotton-seed meal along with bran, died in from two to three weeks. He also admits the possibility of ptomaine poisoning.

At the Alabama station two of Duggar's[c] experiments resulted fatally. In the first experiment the smaller pigs were the first to die. They averaged about 64 pounds, and 12.20 pounds of cotton-seed meal were eaten by each before death ensued. This was 0.25 pound daily per head, or 0.4 pound daily per 100 pounds live weight for forty days, and a total of 18.90 pounds per 100 pounds average live weight. Larger pigs in this experiment, averaging a little over 70 pounds, died when 16.60 pounds of cotton-seed meal had been fed per head. These pigs were fed 0.41 pound per head daily, or 0.53 pound

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[a] Bul. No. 28, Iowa Expt. Sta.

[b] Bul. No. 122, Alabama Expt. Sta.

[c] Bul. No. 76, Arkansas Expt. Sta.

per 100 pounds live weight daily, for forty-three days; the total amount of cotton-seed meal fed was 21.60 per cent of the average live weight. In the second fatal experiment one of the pigs died "after having appeared gaunt and weak for two days." This pig averaged about 60 pounds in weight and up to the time of death had been fed 5.4 pounds of cotton-seed meal. This was a total of 9.2 pounds per 100 pounds live weight. The pig had not had more than 0.25 pound cotton-seed meal daily per 100 pounds live weight. The other pig in the same lot showed an unthrifty condition and the ration was changed. (See the Kansas experience on page 122, where a similarly small amount of cotton-seed meal produced fatal results.) The ration in both experiments was, cotton-seed meal one-fifth, corn meal four-fifths.

In another test with a ration of corn meal three-fourths, cotton-seed meal one-fourth, the pigs were noticed to be out of condition toward the thirty-fifth day, but no deaths occurred. They averaged about 118 pounds in weight, and the amount of cotton-seed meal which made them sick was 25.5 pounds. This was 21.4 pounds per 100 pounds live weight, or 0.61 pound daily per 100 pounds live weight.

The causes of death are regarded by Dinwiddie[a] as being both essential and contributory, the essential cause being the toxic principle supposed to be present. He describes the immediate cause of death as follows:

> In all our cases the immediate cause of death was obviously asphyxia, due to pressure on the lungs by the dropsical effusion into the pleural cavities. In its final manifestations the disease was an acute dropsy of the pleural and pericardial sacs. The congestion of the abdominal organs, and especially of the portal system, can be attributed to obstructed circulation through the collapsed lungs damming the blood back in the venous system, and hence a process secondary to the pleuritic effusion. That this portal engorgement was secondary to the pleural effusion, I infer from the absence of degenerative or other changes in the liver which could account for it and from absence of any marked peritoneal effusion. Ascites would be the first result of such extreme portal congestion if it were primary. All of these conditions, however, are necessarily the result of some fundamental cause, the nature of which is yet to be discovered. An acute hydrothorax and hydrops pericardii, unaccompanied by ascites and without any antecedent pleuritis, is a condition rarely met with in human pathology. Non-inflammatory dropsical effusion may be due to mechanical obstruction, cardiac disease, degenerative changes in the kidney or liver, or to physical or chemical changes in the blood itself. Neither of the first three causes appears to be in operation here. Further researches will probably show some grave alteration in the composition of the blood as the primary effect of acute cotton-seed meal poisoning. In hogs, at least, nervous derangements are not manifested, so far as I have seen.

Points that may in time lead to the discovery of the trouble are that old meal seems to be more fatal than fresh, that cotton-seed meal is more fatal than cotton seed in any condition, and that the poisonous agent is not in the oil, but seems to be entirely left in the cake

[a] Bul. No. 76, Arkansas Expt. Sta.

when the oil is expressed. It is also well known throughout the South that decomposed cotton seed has little, if any, dangerous character, and it has been pretty clearly established by the studies of Curtiss[a] and by the experience of practical feeders that the meal is so changed by the processes of digestion that hogs following steers which are being fed a heavy cotton-seed meal ration are not injured by the droppings.

Feeding value.—Disregarding, for the moment, the fatal effects of this product, let us consider its feeding value. The results from feeding either the whole grain or the meal have not been uniform, and have given rise to three opinions regarding its value as a pig feed—(1) that it is both worthless and dangerous; (2) that it is only fairly valuable and hardly worth the risk of feeding, and (3) that it is extremely valuable if means can be devised to feed it without fatal results.

The Kentucky Experiment Station[b] fed a ration of 1 part cotton-seed meal, 1 part wheat bran, and 2 parts corn-and-cob meal for twenty-eight days, when ship stuff replaced the cotton-seed meal, because the pigs refused it, whether fed wet or dry. No fatalities were reported, but the gains were unsatisfactory and the station came to the conclusion that, in Kentucky, "cotton-seed meal could not be fed profitably to hogs, whether for growth or fat."

Curtis[c] expresses himself in a similar tone, that, "After two years successive tests in feeding cotton seed and cotton-seed meal to hogs with a definite aim in view, and after practical attempts to use these products in a similar manner for the past ten years, we do not hesitate to express our candid opinion that there is no profit whatever in feeding cotton seed in any form or cotton-seed meal to hogs of any age; * * * that it is practically impossible to prepare cotton seed or cotton-seed meal in any manner so that hogs will eat it greedily."

Lloyd's[d] opinion, from his experience at the Mississippi Station, is somewhat similar. He had losses from raw cotton-seed meal, but none from those getting cooked seed, although these pigs became very sick and refused to eat. His gains were "neither satisfactory nor profitable." With one bunch of pigs the average daily gain was about 1 pound for the first two weeks, after which the gains were small, although the pigs did not lose their appetite and continued to eat with relish. The after effects of feeding in this case were detrimental, as the pigs never got into good condition.

At the North Carolina Station, Emery[e] fed an 88-pound pig for sixty-one consecutive days on a cotton-seed meal ration, the amount of cotton-seed meal varying from one-fourth pound daily at the beginning to 2 pounds daily at the close. Skim milk was fed during

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[a] Bul. No. 28, Iowa Expt. Sta.
[b] Bul. No. 19.
[c] Bul. No. 21, Texas Expt. Sta.
[d] Bul. No. 60.
[e] Bul. No. 109.

the first three weeks and green feed during the first six weeks. Two pounds of cotton-seed meal daily made the pig sick, and for twenty-two days the meal was dropped from the ration. Then the feed was made one-fourth cotton-seed meal, three-fourths wheat bran, with 12 pounds skim milk daily for ten days, after which corn meal was substituted for the cotton-seed meal. The feeding was unprofitable, but the pig did not die.

Among the instances where feeding was fairly profitable, the results at the New York (State) Station[a] may be noted. The intention was not to note the effects of cotton-seed meal feeding. Cotton-seed meal in amounts varying from one-thirteenth to three-tenths of the entire ration was fed, with good results, covering periods of from fifty-six to one hundred and thirty-nine days. Two pigs in a lot fed on wet feed were troubled with indigestion, and after the close of the trial one of them died from "congestion of the liver, following indigestion." This may have been cotton-seed meal poisoning. The pigs were on a ration in which there was three-tenths pound daily for sixty-three days.

Cary's[b] results in Alabama are remarkable because of the large quantities of cotton seed fed. He conducted three experiments in which cotton seed or cotton-seed meal were fed to 13 pigs. From 1½ to 4½ pounds of crushed cotton seed were fed per head daily. In two instances cotton-seed meal was fed, but in small amounts (three-tenths pound daily in one case and three-fifths pound in the other). The pigs receiving cotton-seed meal did not thrive, losing appetite; one of them received bran, the other corn meal in addition to the cotton-seed meal, and both had green feed. When they were taken from cotton-seed meal and placed on corn and pasture they recovered rapidly.

In the first test the pigs on crushed cotton seed made fairly good gains. They had some grain in addition, and all received green or succulent feed. In the second test 3 pigs were fed rations of corn meal and crushed cotton seed or ground cowpeas and crushed cotton seed. The rations were heavy—6 pounds when corn meal was fed and 6½ pounds when cowpeas were fed; the amount of cotton seed was more than half the ration. Fair gains were made and the after effect does not seem to have been serious, as the pigs did well when placed on pasture and fed corn. One pig in this lot had crushed cotton seed alone, being fed 4½ pounds daily. He lost in weight, but gained in size of frame. When turned on pasture and given corn he did well. Another pig that had 3½ pounds crushed cotton seed and 3½ pounds green rye daily lost 28 pounds in twenty-eight days. After the rye was discontinued the pig failed to thrive, but recuperated rapidly on pasture with corn.

In three cases where 3 pounds of crushed cotton seed were fed daily, with ground cowpeas and green rye or corn meal and green rye,

[a] Eleventh and Twelfth An. Rpts. [b] Bul. No. 68, Alabama Expt. Sta.

nominal gains were made. No disastrous effects followed when green feed was discontinued; subsequent treatment on pasture and corn gave good gains.

In a third test 2 pigs were fed for forty-nine days on a daily ration of 6 pounds of separator milk and 3½ pounds crushed cotton seed, then for fifty days on 6 pounds of whole milk and 3½ pounds crushed cotton seed. Their appetites failed twice, but they gained slightly in weight.

The length of time that cotton seed or cotton-seed meal was fed in these experiments was one hundred and five days in the first, ninety-one days in the second, and one hundred and nine days in the third. Although the pigs were occasionally off feed there were no fatalities.

Duggar's[a] experiments did not show very favorable results for cotton-seed meal as part of the pig's ration. In no case did the pigs so fed make so great an average daily gain as 1 pound, and the gains were usually expensive, whether the grain was fed alone or with green feed. Rations of corn meal only gave better results. One lot of 2 pigs, averaging 68 pounds, fed a ration of cotton-seed meal one-fifth, corn meal four-fifths, and grazed on sorghum, made an average daily gain of 0.53 pound for thirty-four days, at an outlay of 380 pounds of grain for 100 pounds gain. Another, averaging 68 pounds, on the same grain ration, but grazing peanuts, made an average daily gain for thirty-eight days of 0.94 pound, requiring 185 pounds grain for 100 pounds gain. Another lot made an average daily gain of 0.8 pound for twenty-eight days on a ration of cotton-seed meal one-fourth and corn meal three-fourths, requiring 384 pounds grain for 100 pounds gain, while a lot on corn meal only in the same test made an average daily gain of 1.1 pounds, but required 531 pounds grain for 100 pounds gain. Duggar found corn meal alone a more palatable ration than one to which cotton-seed meal had been added, and had difficulty in inducing pigs to eat a full allowance of a cotton-seed meal ration.

The Kentucky, Wisconsin, Iowa, Kansas, and Oklahoma experiment stations have published results that show cotton-seed meal to have considerable feeding value for pigs.

In Kentucky May[b] fed cotton-seed meal at intervals of one week as part of the ration to 20 grade Berkshire pigs during a three weeks' finishing period with very good results.

At the Wisconsin Station,[c] Henry fed two lots of 5 pigs each for thirty-five days on a ration of which one-half pound daily was cotton-seed meal. The feeding was alternated, one lot receiving oil meal while the other had cotton-seed meal. The rest of the grain ration was a mixture of equal parts of wheat shorts and corn meal. Skim milk and whey were fed, and the feeding was done in the fall and

[a] Bul. No. 122, Alabama Expt. Sta.
[b] Bul. No. 101, Kentucky Expt. Sta.
[c] Eleventh An. Rpt.

winter. The pigs were never sick nor off feed, and made their gains economically. The tabulation of results shows that while on cotton-seed meal the pigs required 5 per cent less feed than while on oil meal.

At the Iowa Experiment Station, Curtiss[a] fed two lots of 3 Poland China pigs each on a ration of corn-and-cob meal, cotton-seed meal, and buttermilk. One lot received one-half pound cotton-seed meal per head daily and the other 1 pound per head daily. The grain fed was soaked for twelve hours before feeding. Salt and ashes were also given. Everything went well until the sixth week, when the droppings of the pigs on the heavy ration became dark in color and somewhat hard. However, the appetite was not affected. The first pig died fifty-one days after feeding commenced, and a second went the day following. They had been on the heavy ration, but showed no signs of sickness, and their gains had been steady. Sixty-three days after the start a pig in the lot receiving one-half pound of cottonseed meal per head daily died, but not without symptoms of trouble. For a day or two before death he had shown a "failing appetite and quickened breathing." The rest of the pigs in this lot showed the same symptoms, but survived, although their gains were light. The Station veterinarian could find no assignable cause of death.

In this experiment the fatal quality of cotton-seed meal seemed to depend, to a certain extent, on the quantity fed. The first pigs to die were those in the lots receiving the heavier ration of cotton-seed meal. These pigs also made the better gains.

The Kansas Station[b] fed 4 small pigs a ration of one-sixth cotton-seed meal and five-sixths corn meal. The meal was stirred in water at feeding time. It was not relished at first, but when it was once eaten rapid gains were made. The first pig died twenty-three days after the feeding began, and "could not have eaten more than 5 pounds of cotton-seed meal altogether," a fact which seems to lessen the weight of the theory that the quantity eaten has an influence on the fatal property of the feed. This pig weighed about 18 pounds at the time of its death. The last pig died on the forty-sixth day of the experiment. (See Duggar's experiments, pp. 117, 118.)

Two sows weighing, respectively, 135 and 308 pounds were put on a ration of one-fourth cotton-seed meal and three-fourths corn meal for forty-five days; they gained 89 pounds each without signs of poisoning.

In a second test, 6 pigs that had been stunted by exclusive corn meal or ground wheat feeding were divided into two lots of 3 each and put on rations composed of one-fourth cotton-seed meal and three-fourths corn meal for one lot, and equal parts of these meals for the other lot. The change of condition is described as "magical" and

[a] Bul. No. 28. [b] Bul. No. 53.

immediate; the pigs began to gain in weight at once, and those receiving the greater amount of cotton-seed meal made the larger gains. No other feed was given. The first pig died on the forty-fifth day of the experiment, the second on the forty-eighth day, the third on the fifty-third day, and the fourth on the fifty-sixth day from the beginning of the cotton-seed meal feeding. Two pigs were left in each lot; they were placed on green oats and then thrived nicely.

A later bulletin[a] from the Kansas Station mentions a lot of pigs that had done poorly in another experiment; they were fed cotton-seed meal, and were "ready for market, well finished, in twenty-two days." At the Kansas Station cotton-seed meal is very highly regarded to put pigs in high condition, if fed for a short time in small quantities. The beginning ration is one-fourth pound cotton-seed meal to each 1,000 pounds live weight per day, which is increased in ten days to make the amount 3 pounds per 1,000 pounds live weight.[b] The meal is mixed with the rest of the grain.

The Kansas and Iowa results show that a cotton-seed meal ration is valuable if the cotton-seed meal is used in a moderate amount and for a limited time. The proportions of cotton-seed meal used in the Iowa test were about one-eighteenth and one-ninth of the total grain rations at the start and about one-tenth and one-fifth at the close. Up to the time the pigs began to die the gains of those on the heavier cotton-seed meal ration were the larger and more economical (1.4 pounds average daily gain and 343 pounds meal and 250 pounds milk per 100 pounds gain). The lighter ration was about equal in results to one of corn-and-cob meal, gluten meal, and buttermilk, that stood second to the heavy cotton-seed meal ration. The two lots returned in pounds of gain per 100 pounds of dry matter in the feed (before deaths began) 31.1 pounds and 26.4 pounds, respectively, for the pigs on the heavy and the light rations. In the Kansas tests the gains before deaths commenced were also very economical; they varied in cost from considerably less than 300 pounds grain per 100 pounds gain in the case of the pigs that had been previously on the single-grain rations to 350 pounds grain per 100 pounds gain in the case of the sows.

Pigs following steers on cotton-seed meal.—Evidence of the dangerous properties of cotton-seed meal for pigs, when they are following steers whose ration is made up wholly or in part of cotton-seed meal, is conflicting. In the Iowa test[c] a lot of 3 pigs followed steers for seventeen weeks that were receiving from 4 to 7 pounds of cotton-seed meal daily. They had very little feed except what they picked up behind the steers, yet there were no noticeable injurious effects.

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[a] Bul. No. 95.

[b] This is about the ration furnished dairy cows in milk.

[c] Bul. No. 28, Iowa Expt. Sta.

The Kansas Station[a] states that the meal used in their early experiments was shipped in from Texas during the previous winter by a local feeder, to be fed to steers. He turned about 40 hogs after them, and all died in the course of six or seven weeks. Considerable evidence that pigs may not suffer after steers that are fed on cotton-seed meal has recently been presented in the columns of the agricultural press.

THE OKLAHOMA EXPERIMENTS.

The Oklahoma Station has made an extensive study of the possibility of feeding this by-product so that good returns may be obtained with little or no danger from poisoning. The conditions under which it has been found that cotton-seed meal may generally be fed safely are (1) where pigs have access to range and plenty of green pasture, and (2) where periods of cotton-seed meal feeding of three to four weeks' duration without pasture are alternated with a period on pasture or on a ration from which the cotton-seed meal has been omitted.

Following up this system the Oklahoma Station has conducted three experiments. In the first trial, in 1900, the alternating method was tried with 17 thrifty shoats of various sizes.[b] They were put on a ration composed of one-fifth cotton-seed meal and four-fifths Kafir-corn meal and had the run of a large paddock, where they got a little green stuff. The trial began March 22. For twenty-seven days the cotton-seed meal ration was fed; then for fourteen days Kafir-corn meal alone, next fourteen days on one-fifth cotton-seed meal, and four-fifths Kafir-corn meal, then seven days without the cotton-seed meal, closing with five days on the original ration. "None of the pigs had died, and all made very fair gains on a moderate amount of grain." At the close of this trial part of the pigs were sold and the rest continued on the cotton-seed meal ration, with which the trial closed (one-fifth cotton-seed meal and four-fifths Kafir-corn meal). They were fed on this ration without change until July 14 with the loss of 1 pig only.

In the second trial of the same year 16 stunted shoats, about a year old and averaging 79 pounds were used. For twenty-six days from April 12, they were hurdled on wheat and fed a light ration of one-fifth cotton-seed meal and four-fifths Kafir-corn meal. There was no ill effect from the grain ration. The gains averaged 0.96 pound per head daily and were made economically. On May 8 the pigs were taken from the wheat and fed the same grain ration in a lot for twenty-one days with no serious results, making an average daily gain of 1.71 pounds at the expense of 307 pounds of grain for 100 pounds gain. Five of the largest were sold after forty-seven days continuous feeding on a cotton-seed meal ration.

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[a] Bul. No. 53. [b] An. Rpt., 1900–01.

The 11 pigs remaining were then given range and green feed and the same grain ration continued. The gains made were satisfactory. There were no losses, and they were sold on July 14, after ninety-three days' continuous feeding on a cotton-seed meal ration.

In 1901, 16 uniform Poland China shoats, farrowed late in the previous fall, were used.[a] They were about 11 weeks old at the beginning of the experiment and averaged about 47 pounds in weight. The experiment began January 11. The pigs were divided into four lots of 4 each. Each lot was given an open pen 9 by 24 feet, and had a space 8 by 8 feet in an inclosed piggery. Cob charcoal, wood ashes, and salt were always accessible; water only was given to drink, and the grain was mixed with water into the form of a thick slop just before feeding. From July 14 to April 1, 2 pounds of sugar beets were allowed each pig daily. The pigs were fed as follows: Lot I received corn meal only to April 5, then a mixture of one-fifth cotton-seed meal and four-fifths corn meal for four weeks, closing with two weeks on corn meal; Lot II received one-third corn meal and two-thirds wheat middlings; Lot III received one-fifth cotton-seed meal and four-fifths corn meal. Lot IV received one-fifth cotton-seed meal and four-fifths corn meal for four weeks, then corn meal for two weeks, next the cotton-seed meal mixture for four weeks, then back to corn meal only for two weeks, and alternating in this manner until the experiment closed.

The only signs of lack of appetite were in Lot I, where exclusive corn-meal feeding proved rather severe for such young pigs, and in Lot III, where a dullness of appetite was noticed for about two weeks. This was only temporary. One pig in Lot IV died on February 15, one week after it had been taken from the cotton-seed meal ration and placed on corn meal, and 2 pigs in Lot III died on February 20, after they had been on a cotton-seed meal ration continuously for forty days.[b] "No further losses occurred, * * * and the pigs thrived and made good gains." One pig in Lot IV showed symptons of sickness, but recovered.

After April 5, Lot I was given the same management and feed as Lot IV, but there were no injurious results. On the contrary, their gains increased. This was also noticed with Lot IV. During the periods that the hogs were on a straight corn-meal ration, except during the closing period, when their greater maturity enabled them to make use of a more carbonaceous ration, the gains were light and expensive, but when the cotton-seed mixture was resumed the gains were large and economical, disregarding the effect of loss by death.

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[a] An. Rpt.. 1901–02.

[b] Dinwiddie had a similar experience. See Bul. No. 76, p. 147, Arkansas Expt. Sta.

The following table shows the results of the one hundred and twenty-six days feeding for the pigs that survived:

Feeding pigs on cotton-seed meal rations.

Ration.	Number of pigs.	Average weight at beginning, January 11.	Average weight at close, May 17.	Average gain.	Average daily gain.	Average amount grain eaten.	Grain per 100 pounds gain.	Cost of grain per 100 pounds gain.
Lot I:		*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Dollars.*
Corn meal	4	46	125	78	0.62	368	470	2.61
Lot II:								
Corn meal $\frac{1}{2}$ / Wheat middling $\frac{1}{2}$	4	46	191	146	1.15	539	370	2.87
Lot III:								
Cotton-seed meal $\frac{1}{5}$ / Corn meal $\frac{4}{5}$	2	47	182	135	1.07	483	357	2.24
Lot IV:								
Alternate rations.	3	44	178	134	1.06	433	368	2.14

Burtis and Malone suggest that had the cotton-seed meal lots been running on green pasture from the beginning of the experiment no losses would have occurred. They also suggest the probability that a ration of one-tenth to one-fifth cotton-seed meal may be fed for an indefinite time if pigs have the run of green pasture.

THE ARKANSAS EXPERIMENTS.

In addition to throwing light on the pathological features of cotton-seed poisoning, Dinwiddie[a] has corroborated the results of those stations, which have shown that, when properly fed, cotton-seed meal is a valuable pig feed, if losses can be avoided. In the experiments in which all the pigs died, Lot I received a ration of cotton-seed meal 1 part and corn chops 3 parts; Lot II received cotton-seed meal 1 part, and corn meal 3 parts, with roots; Lot III received cotton-seed meal 1 part and wheat bran 3 parts, and Lot IV received bran 1 part and corn chops 3 parts. There were three pigs in each pen, and feeding began January 1, 1902. The pigs were confined in pens with an open shed for shelter, were watered and fed twice daily, and had a mixture of hard-wood ashes and salt supplied constantly. The results are tabulated as follows:

Feeding pigs on cotton-seed meal rations.

Lot.	Number of days until first death.	Eaten per head.	Eaten daily per head.	Eaten daily to initial weight.	Initial weight.	Daily gain per head	Daily gain to initial weight.
		Pounds.	*Pounds*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*
Lot I	35	23	.68	1.6	41	0.9	2.2
Lot II	40	25	.64	1.5	42	1	2.4
Lot III	61	45	.80	1.6	48	1	2.1
Lot IV					47	.9	1.9

[a] Bul. No. 76, Arkansas Expt. Sta.

Dinwiddie points out particularly that a corn-meal and cotton-seed-meal ration, which one would naturally select as giving the proper proportions between nitrogenous and carbohydrate constituents, proved the most fatal in his experiments, and that the bran and cotton-seed meal ration, the most nitrogenous of the three, required the most time for the dangerous property to assert itself. Contrary to what one would expect from the Oklahoma results, roots did not have so good an effect as the wheat bran.

The pigs received from 0.64 to 0.8 pound of cotton seed per head daily, which was from 1.5 to 1.6 per cent of their initial body weight. The first death occurred in the case of the pigs on corn and cotton-seed meal thirty-five days after the feeding commenced, an average of 23 pounds cotton-seed meal being eaten per head. In the case of the pigs fed corn, cotton-seed meal, and roots, the first death was forty days after the beginning, an average per head of 25 pounds of cotton-seed meal being eaten. The first death in the case of the pigs on bran and cotton-seed meal occurred sixty-one days after the beginning, 45 pounds of cotton-seed meal being eaten per head. Up to the time of death the gains of the pigs on cotton-seed meal were as good or better than those of the pigs on corn chops and bran (Lot IV).

Following the experiment in which all the pigs on cotton-seed meal died, Dinwiddie[a] fed 4 native pigs, averaging about 50 pounds in weight, on various rations, cotton-seed meal being a prominent factor, constituting one-fourth of the ration. Turnips were fed for eighty days, after which rye, oats, and alfalfa were given for two months. The pigs were fed from February 26 to November 6, 1902. Only 1 received cotton-seed meal throughout the experiment, and for a small part of the time none was given to it. The other pigs received rations of equal parts of bran and corn meal or ear corn after being taken from the cotton-seed-meal ration.

Dinwiddie presents the following tabulation of the results of this experiment:

Feeding pigs on cotton-seed meal rations.

Designation of pig.	Number of days fed cotton-seed meal.	Weight of cotton-seed meal eaten.	Weight of cotton-seed meal eaten daily in first period (80 days).	Daily consumption of cotton-seed meal to initial weight.	Weight of cotton-seed meal eaten daily in second period (59 days).	Weight of cotton-seed meal eaten daily for remainder of test.
		Pounds.	*Pounds.*	*Per cent.*	*Pounds.*	*Pounds.*
A	139	80	0.58	1.4	[a] 0.55	----------
B	248	242	.58	1.4	.55	[b] 1.5
C	198	137	.58	1.4	.55	[c] 1
D	198	137	.58	1.4	.55	[c] 1

[a] Decrease probably due to a larger supply of green feed.
[b] One hundred days. (Cotton-seed meal 1, corn meal 3.)
[c] Fifty-nine days.

A third test[a] was made in which rations of cotton-seed meal 1 part and bran 3 parts and cotton-seed meal 1 part and wheat chops 3 parts

[a] Bul. No. 76, Arkansas Expt. Sta.

were fed. The former ration was fed for ninety-five days to 6 pigs, which averaged about 50 pounds in weight. The latter was given for ninety-nine days to 4 Tamworth pigs, averaging about 50 pounds in weight. The following table shows the results:

Feeding pigs on cotton-seed-meal rations.

Ration.	Number of pigs.	Time fed cotton-seed meal.	Average amount cotton-seed meal eaten.	Average amount cotton-seed meal eaten during first month.	Cotton-seed meal to estimated initial body weight.	Average amount cotton-seed meal eaten daily after first month.	Cotton-seed meal eaten daily during test.
		Days.	*Pounds.*	*Pounds.*	*Per cent.*	*Pounds.*	*Pounds.*
Cotton-seed meal 1, bran 3	6	95	54	0.4	0.8	0.6	0.5
Cotton-seed meal 1, wheat chops 3	4	99	57	[a].4	18	[b].7	.5

[a] First half of period. [b] Last half of period.

There were no losses from these rations, and the pigs made small gains.

Effect of cotton-seed meal on pregnant sows.—Dinwiddie[a] fed a native sow carrying her third litter on a ration of cotton-seed meal 1 part and bran 3 parts for eighty days before farrowing. She ate a total amount of 112 pounds of cotton-seed meal, which was 1.39 pounds daily and 0.8 per cent of the estimated initial body weight. The ration agreed with her and there appeared to be no harmful effects on the fetal litter, it being farrowed safely, with no stillbirths.

Effect of crude cotton oil.—Dinwiddie[a] fed 3 pigs on a ration of corn meal 1 part, wheat bran 2 parts, and crude cotton oil 0.1 to 0.4 part. The amount of cotton oil fed (estimating the fat content of cotton-seed meal at 14 per cent) was equivalent to that contained in from 0.25 to 1.8 pounds of cotton-seed meal, the smaller amount having proved fatal in the Arkansas results, already discussed. These pigs were on the cotton-oil ration one hundred and forty-four days. The amount of oil fed for the entire time to each pig was 21 pounds, equivalent to 150 pounds of cotton-seed meal. The average daily amount of oil consumed varied from 0.06 pound (meal equivalent, 0.4 pound) to 0.24 pound (meal equivalent, 1.6 pounds). The average daily amount of oil fed for the entire test was 0.14 pound (meal equivalent, 1 pound). The pigs made an average daily gain of 0.6 pound, and suffered no serious effects from the oil.

Use of cotton-seed meal in the feed lot.—The use of cotton-seed meal in the feed lot must be very carefully guarded, especially until the conditions under which it may be used without danger and the circumstances which govern the demonstration of its poisonous properties are more thoroughly understood. The feeding of the cotton-seed meal which the South produces is one of the greatest problems of agri-

[a] Bul. No. 76, Arkansas Expt. Sta.

culture in that section yet to be solved satisfactorily. It is not difficult to appreciate what may be gained if some of this by-product, which has such high feeding and fertilizing value, and which is exported in such enormous quantities, can be converted into pork products, which are now largely imported from other States.

PACKING-HOUSE PRODUCTS.

The frugality of the modern meat packer has become almost proverbial. Less than twenty years ago the disposal of the offal of slaughtering was a problem, but at present there is very little waste, and the packer has actually come to regard the by-products as the principal source of profit in his business. The preparation of these by-products for use as animal feed is one of the later developments of this branch of the industry. Fertilizers have long been prominent in the sales, the material that enters into their composition being meat scraps, blood, bone, hair, intestinal contents, etc. The use of tankage, a by-product that has had its sale entirely as a fertilizer, is growing among pig feeders, and has been studied by Plumb and Van Norman at the Indiana Station, and by Kennedy and Marshall at the Iowa Station. Beef meal is also a packing-house product, whose feeding value was studied along with that of tankage in the Iowa experiment.

Character of packing-house by-products.—Plumb and Van Norman[a] state that tankage may contain scraps of meat, intestines, and their contents, hair, etc. It is classed as *concentrated* and *crushed* tankage. Concentrated tankage is not used for animal food. Crushed tankage is said to be of several grades, being graded according to the ammonia and phosphoric-acid content, although it is probable that the tankage graded as No. 1 is free from the contents of intestines.

Kennedy and Marshall[b] used two brands of tankage made by Chicago packers. One of these is described as follows:

> Digester tankage is made from meat scraps, fat trimmings, and scrap bones. These are taken up as fast as taken from the animals and put into a large steel tank and cooked under a live steam pressure of 40 pounds to the square inch, which cooks out the tallow. After the steam is turned off it is allowed to settle, when the grease rises to the top and is drawn off. After the grease is drawn off the tankage is kept agitated, and by evaporation the water is extracted until the tankage contains about 8 per cent moisture. It is then taken out of the tank, allowed to cool, is ground, and stored ready for shipment. This tankage is supposed to contain about 60 per cent protein and 10 per cent fat.

The manufacture of the other tankage is thus described:

> This product, like the one just described, is made from meat scraps, scrap bones, etc. Quoting the words of the manufacturer, it is as follows: "Tankage is the product which drops to the bottom in our rendering tanks when we are rendering out grease, tallow, etc., at our various packing houses. It has been thoroughly cooked under 40 pounds pressure for several hours, which thoroughly destroys any disease germs which might possibly be in the raw meat. This product is

[a] Bul. No. 90, Indiana Expt. Sta. [b] Bul. No. 65, Iowa Expt. Sta.

pressed and then dried in steam driers at a high temperature. It is then ground and shipped in 100 and 200 pound sacks."

The beef meal, used in the Iowa[a] test, is described as follows:

This product is made from scraps of meat and bone from which the grease has been extracted and the liquors concentrated by cooking. These are then pressed, dried, and ground in preparation for the market. It is claimed to contain from 40 per cent to 50 per cent of protein.

Analyses of packing house by-products.—The analysis of tankage reported by the Indiana Station is as follows:

	Per cent.
Moisture	8.63
Protein	49.81
Ether extract	15.78
Crude fiber	4.78
Nitrogen-free extract	5.06
Ash	15.94
	100

The Iowa Station analyses, including that of the corn meal used, are as follows:

Analyses of feeding stuffs. (*Weems.*)[a]

Ration.	Water.	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Corn meal	11.05	1.55	15.25	4.85	63.80	3.50
Beef meal	6.10	15.60	61.10	5.20	3.12	8.88
Tankage	6.25	12.85	42.15	6.95	15.50	16.30
Do	9.05	20.65	39.10	10.90	8.60	11.70

[a] Bul. No. 65, Iowa Expt. Sta.

Feeding tankage in a corn-meal ration.—In the Indiana[b] experiment 16 young pigs were fed to determine the value of tankage. The pigs were purebred Poland Chinas and Berkshires. There were 4 lots, 2 of each breed in each lot. The tankage was specially prepared by the packers who furnished it to the experiment station, and was "made from bones and meat taken from the cutting room, tanked immediately, and pressed and dried."

The conditions of the experiment were equal for all lots; all had an opportunity for getting exercise and each lot was in a separate inclosure. There was no sickness and Lot III was the only one showing lack of appetite at any time. The pigs were fed as follows: Lot I, 10 parts corn meal and 1 part tankage; Lot II, 5 parts corn meal and 1 part tankage; Lot III, corn meal; Lot IV, 10 parts of a mixture of equal parts of corn meal and shorts and 1 part tankage. The feed was weighed out and then mixed with tepid water in the proportion of about 2 parts of water to 1 part of feed, a slop of medium thinness being made. Each lot of pigs had access to ashes and salt. The cost

[a] Bul. No. 65, Iowa Expt. Sta. [b] Bul. No. 90, Indiana Expt. Sta.

of feed used was as follows: Corn meal, $20 per ton; shorts, $16 per ton; tankage, $30 per ton.

At the Iowa Station[a] five lots of 6 pigs each, averaging 205 pounds, were fed for forty-nine days, to note the value of packing-house products. "Each lot contained 3 crossbred Poland China-Yorkshires, 2 Poland China-Duroc Jerseys, and 1 Poland China-Berkshire." Corn was used as the basis of comparison and the pigs were fed as follows: Lot I received corn meal alone; Lot II received about 5 parts of corn meal and 1 part of beef meal;[b] Lot III received about 5 parts of corn meal and 1 part of digester tankage; Lot IV received about 5 parts of corn meal and 1 part of tankage.

The market prices of the corn meal and tankage are given as follows: Corn meal, $22 per ton; digester tankage, $32 per ton; tankage, $25 per ton.

The Iowa pigs were shipped to Chicago and the lots were sold separately. They brought $7.55, the extreme top of the market for the day of sale.

The following table shows the results of these experiments:

Tankage in a corn-meal ration for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed eaten.		Feed per 100 pounds gain.		Cost per 100 pounds gain.
						Grain.	Tankage.	Grain.	Tankage.	
Indiana:		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dollars.*
Corn meal 10, Tankage 1	4	59	589	127	1.16	1,982	197	337	33	3.80
Corn meal 5, Tankage 1	4	58	625	127	1.23	1,984	379	317	61	4.00
Corn meal	4	58	342	127	.67	1,779	.....	520	.....	5.20
Corn meal and shorts 10, Tankage 1	4	58	579	127	1.14	2,001	199	346	34	3.60
Iowa:										
Corn meal	6	197	596	49	2.08	2,747	.....	461	.....	5.10
Corn meal and digester tankage	6	202	757	49	2.57	2,429	458	321	61	4.50
Corn meal, Tankage	6	198	668	49	2.27	2,438	460	365	69	4.90

These experiments seem to show that tankage has a great deal of value for balancing a pig's ration.

In the Indiana test the use of tankage lessened the amount of grain required per 100 pounds gain from 203 pounds to 175 pounds—from 38.9 to 33.5 per cent—showing tankage to be very profitable with the prices that were charged for grain in this instance.

[a] Bul. No. 65.

[b] One lot of pigs in this experiment were fed to note the value of condimental feeds. (See pp. 133, 134 for the results.)

In the Iowa test 140 pounds and 96 pounds, respectively, were saved by the use of tankage—30.4 and 20.8 per cent—not so good a record as obtained in Indiana. The difference between the money cost per 100 pounds of the corn-fed and tankage-fed lots was also much less than in Indiana.

The condition of the pigs in the Indiana test was remarked upon. The tankage-fed pigs handled better, had finer, silkier coats, and ate with much more relish than those on corn alone. The corn-fed lot was conspicuous by reason of its poor condition.

At the conclusion of their experiments, Plumb and Van Norman gave the pigs that had been on corn meal a ration of 5 parts of corn meal and 1 part tankage for forty-nine days. There was immediate improvement in their appetites, the hair softened, and the skin handled better. There was a marked improvement in growth, which contrasted strongly with the gains made while on corn meal only.

Experimenters caution stockmen to use that tankage only which has been specially prepared for feeding purposes.

Beef meal in a corn meal ration.—The results of the lot of pigs that were fed beef meal at the Iowa Station are compared below with those on corn meal. The price of the beef meal used in this test was $22 per ton.

Beef meal in a corn-meal ration for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed eaten.		Feed per 100 pounds gain.		Cost per 100 pounds gain.
						Grain.	Beef meal.	Grain.	Beef meal.	
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*
Corn meal	6	197	596	49	2.08	2,747	.....	461	.....	5.10
Corn meal 5 parts, beef meal 1 part	6	197	707	49	2.40	2,448	458	346	65	4.80

Beef meal, like tankage, seems to be valuable in the pig's ration. The amount of grain saved per 100 pounds gain by the use of beef meal was 115 pounds, or 24.9 per cent.

SUGAR BY-PRODUCTS.

Feeding beet molasses.—Clinton[a] fed 5 pigs averaging 87 pounds on a ration of corn meal 8 pounds, beet molasses 12 pounds, and skim milk 20 pounds. "This quantity was given in two daily feeds, and the pigs apparently did not relish the molasses, yet they ate it." Three days after feeding commenced they ate the morning feed well, but within an hour 1 pig was dead and another died a few hours later. Postmortem examination indicated poisoning. The surviving pigs were then placed on a corn meal and milk ration, but made expensive gains, the cause assigned being the effect of molasses feeding.

[a] Bul. No. 199, Cornell Univ. Expt. Sta.

This experiment had results similar to those of German investigators with beet molasses. It may be that this by-product is not a safe feed for pigs. However, other molasses by-products in sugar production, such as cane molasses, are valuable for feeding horses, cattle, and sheep, and many farmers value highly the "skimmings" from sorghum vats as a fattening feed for pigs. There are very few experimental data on the feeding value of the by-products from sugar refining.

CONDIMENTAL FEEDS.

Two experiments are noted which deal with the value of condimental stock feeds in pork production. These feeds have quite general use over the country, and, on account of strict legislative regulations and the supervision and analyses by the experiment stations, they are generally of high feeding value, having a high nutrient content. They are prepared with palatability in view and often contain some harmless drug that increases the attractiveness of the feed and may have a good effect on the digestive functions. They are thus frequently found valuable where animals are being crowded or are suffering from the effects of improper feeding. Oil meal usually forms the basis of these feeds and is supplemented by bran, bean meal, cotton-seed meal, ginger, fenugreek, etc. These feeds range in price per ton from $30 to $500. The manufacturers generally direct that they be used in very small amounts.

Feeding experiments.—At the Indiana Station Plumb[a] fed two lots of 4 pigs each to determine the value of American stock food. The pigs were gilts, four months old. There were 3 Poland Chinas and 1 Chester White in each lot. The experiment lasted one hundred and twenty-two days. Lot I was fed a mixture of equal parts of shorts and hominy feed and a small amount of American stock food; Lot II received the same ration without the stock food. At the Iowa Station Kennedy and Marshall[b] fed two lots of 5 crossbred pigs each averaging 205 pounds. One lot on corn meal and Standard stock food was compared with a lot on corn meal alone. The following are the results of the two tests:

Feeding pigs with and without stock food.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed eaten.		Feed per 100 pounds gain.		Cost per 100 pounds gain.	Profit per pig.
						Grain.	Stock food.	Grain.	Stock food.		
Indiana:	*Lbs.*	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*	*Dolls.*
Stock food	4	66	682	122	1.42	2,547	64	373	9.38	3.00	[c] 9.66
No stock food	4	65	689	122	1.43	2,581	-------	375	-------	2.60	[c] 13.94
Iowa:											
Stock food	5	197	655	49	2.23	2,858	14	436	2.14	5.00	2.64
No stock food	5	197	596	49	2.08	2,747	-------	461	-------	5.10	2.39

[a] Bul. No. 93. [b] Bul. No. 65. [c] Profit per lot.

The Indiana results show that nothing was gained by the use of the prepared feed; in fact, there was indicated a decided disadvantage, as more feed was required per 100 pounds of gain and the profits were very much less than with the lot not having the prepared feed.

The Iowa results show a saving in cost of 10 cents per 100 pounds gain for the pigs receiving Standard stock food and a net profit per pig of 25 cents in favor of this lot as compared with pigs on corn meal alone. It is needless to point out that the results of these two experiments should not be too closely compared. In addition to the stock food given one lot, all the Indiana pigs were on a mixed ration; whereas in the Iowa test the stock food was the only variation from corn meal that was permitted. The results from adding any palatable feed to a straight corn-meal ration will be greater than the addition of the same or a similar feed to a mixed ration, because in the one case variety is the greatest necessity of the ration, while in the other it is already present. The same, if not very much better, results would have been seen had pigs on a ration of corn meal and green or succulent feed or dairy by-products been compared with pigs on a ration of corn meal only; and oil meal would probably have had a similar effect. While some of the difference in results may have been due to a difference in the quality of the two stock foods, it would naturally be expected that not only a better showing in rate and economy of gain for the stock food when conditions resemble those of the Iowa test would be made, but it would also be expected that there would be a relatively greater showing from the standpoint of total feed eaten. Both of these results are manifest; indeed, in the Indiana test the stock food seems to have had no effect whatever on the appetite.

Plumb[a] mentions a test by a student at Purdue University where Rauh's stock food was fed to 3 pigs for thirty-five days, after which they received Standard stock food for forty-nine days. They had equal parts of corn meal and shorts, and were compared with a lot of 3 pigs on corn meal and shorts only. There was a total gain of 2.5 pounds in favor of the prepared food first mentioned. The total balance was 21 pounds of gain in favor of the condimental feed. The results were as follows:

Feeding pigs with and without stock food.

Ration	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed eaten.		Feed per 100 pounds gain.		Cost per 100 pounds gain.	Total profit.
					Grain.	Stock food.	Grain.	Stock food.		
	Pounds.	*Pounds*		*Pounds.*	*Pounds.*	*Ounces.*	*Pounds.*	*Ounces.*	*Dollars.*	*Dollars.*
Stock food	63	387	84	1.54	1,355	100	350	25.8	4.19	6.98
No stock food	63	366	84	1.45	1,325	.....	362	.....	4.22	6.50

[a] Bul. No. 93, Indiana Expt. Sta.

These results favor the stock food in about the same proportion as in the Iowa test.

DAIRY BY-PRODUCTS.

The use of the by-products of the dairy and creamery (skim milk, buttermilk, and whey) is one of the most interesting subjects of study in pork production. The value of the milk is known on every farm, although it may not be fully appreciated, and anyone who has fed pigs knows the keen appetite that these animals have for milk and its products. In the neighborhood of many large dairies pork production has become a very prominent and lucrative branch of the dairy industry.

Regarding solely their chemical composition, the by-products of the dairy contain most of the indispensable feeding constituents of the milk from which they are produced.

The residue from the separation of cream (skim milk) and that from churning (buttermilk) leave two products that contain practically all the protein and carbohydrates of the whole milk. In cheese making, the whey that is left is the least valuable of the dairy by-products, the greater part of the casein and fat of the milk being retained in the cheese. While whey is by no means worthless for feeding purposes, it can readily be seen that if skim milk and buttermilk have higher feeding values for pigs than whey, butter making and pig feeding will more profitably accompany each other than will cheese making and pig feeding. These by-products supply growing material to young animals and provide an excellent nitrogenous balance in the fattening ration. The constituents that remain in the milk after skimming and churning are the most expensive ones, considered from the standpoint of feeding and fertilizing value, and it is largely due to this fact that dairy farming is so often a profitable business when conducted in a thorough manner.

The value of dairy by-products is not alone in their nitrogenous character. They have an effect on the digestion that brings results out of all proportion to their nutritive value. Where pigs have been for a long time on a monotonous ration, such as corn meal alone, they lose appetite, become listless, and sick, and so make very unsatisfactory gains. If skim milk is given, even in very small amounts, an immediate change for the better is noticed—appetite returns and the pigs begin to gain rapidly in weight. As already stated, the gain in weight is out of all proportion to the actual amount of nutrient material in the milk, and this peculiarity has been remarked upon, not only when pigs are fed as indicated above, but also when pigs are fed a varied grain ration and skim milk in comparison with others on the grain ration only. Just why dairy by-products have this effect is not exactly known, but the suggestion has been made that

they keep the digestive system in better order, and thus enable the animal actually to digest a greater percentage of his feed. The same fact has been noticed when roots and green feed are fed. Pasturing on rape, alfalfa, or the grasses probably has a similar effect.

The effect of dairy by-products on the carcass is one of the most important results of such feeding. It is generally admitted that, while excellent hams and bacon may be produced without dairy by-products, the use of these by-products will result in pork of a more nearly uniform high quality.

THE FEEDING VALUE OF DAIRY BY-PRODUCTS.

Comparing grain and milk rations with rations of grain alone and milk alone.—Linfield[a] reports the results of a series of investigations at the Utah Station. In all, seven distinct experiments are given. Except in one experiment, the pigs were confined on the north side of a barn, were furnished plenty of bedding, and allowed a small run. When grain alone was fed it was mixed with water to form a thin slop, and when milk was fed with grain it was mixed in the same manner. The milk was never given sour. The hogs had access to pure water, had charcoal and ashes in the pens, and were fed twice daily. These experiments were conducted primarily with the object of comparing the value of feeding a combination of grain and skim milk with both grain alone and skim milk alone. They varied somewhat in details, and some difficulty seems to have been experienced in obtaining as much milk as the circumstances required.

The grain was fed in various combinations with the milk, and was usually that which was available in that section for feeding purposes. It consisted of equal parts of barley and bran, corn and wheat, wheat and bran, and corn meal and bran, and in two experiments ground wheat. Whey was fed in the fifth, sixth, and seventh experiments; it formed not over 12 per cent of the by-product in the fifth, but was as much as 40 per cent in the last two. It was a matter of remark that the results in these experiments were fully equal to those where skim milk was fed throughout the entire feeding period, which shows that whey has quite a high feeding value.[b] The quantity of skim milk in the lots fed milk and grain in comparison with grain alone or milk alone varied from 4 to 6 pounds of milk per pound of grain fed at the beginning of the experiment, the amount of milk being gradually decreased with the age and weight of the pigs. The pigs used were well bred, usually being Berkshires, Berkshire grades, or Poland China grades. The following table is a summary of these experiments.

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[a] Bul. No. 57.

[b] See Ontario Agricultural College experiments with sweet and sour whey, pp. 147, 148.

Economy of skim-milk feeding.[a]

Ration.	Number of tests.	Number of pigs.	Average weight at beginning.	Average gain.	Number of days fed.	Average daily gain.
			Pounds.	*Pounds.*		*Pounds.*
Milk and grain	8	27	40	169	133	1.27
Grain	5	15	63	110	121	.91
Milk	4	11	39	74	108	.68

Ration.	Feed eaten per 100 pounds gain.		Dry matter per 100 pounds gain.	Digestible dry matter per 100 pounds gain.	100 pounds milk equal pounds gain.	Average amount feed eaten per day.	
	Grain.	Milk.				Grain.	Milk.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Milk and grain	292	768	334	258	23.2	3.73	9.74
Grain	470	.....	421	319	.....	4.41	.....
Milk	.....	3,312	298	285	14.2	.....	22.28

[a] Bul. No. 57, Utah Expt. Sta.

These results indicate that, in rate of gain, an average of eight tests with a grain-and-milk ration shows gains made one-third faster than in five tests with grain alone, and nearly twice as rapidly as in four tests with milk alone. The least amount of dry matter required for 100 pounds of gain was that with the pigs on milk alone, but the pigs on grain and milk required the least digestible dry matter per 100 pounds gain. The returns from skim-milk feeding are estimated by Linfield at 17 cents per 100 pounds of skim milk when grain and milk were fed and 10 cents per 100 pounds of skim milk when milk alone was fed, grain being valued at 75 cents per 100 pounds.

These experiments show that pigs fed on grain and milk are enabled to eat much more feed than those on grain alone; those on grain and milk ate 4.24 pounds of dry matter per head daily; the pigs on grain alone 3.93 pounds of dry matter per head daily, and the daily average of the pigs on milk alone was only 2 pounds of dry matter. This is a point of great importance, and, with the figures showing rate and economy of gains, illustrates the fact that skim milk fed to pigs with grain enables them to eat more feed and to make more gain than pigs on grain alone.

The unsatisfactory character of the gains made by the pigs on skim milk alone is very apparent. This method of feeding should never be resorted to.

Corn and dairy by-products.—At the Tennessee Station Soule and Fain[a] fed four lots of pigs to compare a corn-meal and water ration with others, in which skim milk and whey were used. The pigs were high-grade Chester Whites and were confined in pens. The rations were as follows: Lot I was fed 6 pounds of corn meal and 10 pounds of water at the beginning of the experiment, increasing to 8 pounds of corn meal and 16 pounds of water toward the close. Lot II had 6

[a] Vol. XV, Bul. No. 1.

pounds of corn meal and 18 pounds of skim milk at the beginning, increasing to 8 pounds of corn meal and 40 pounds of skim milk toward the close. Lot III had 4 pounds of corn meal and 12 pounds of skim milk for the first fifteen days and 1.75 pounds of wheat meal, 6.25 pounds of corn meal, and 40 pounds of whey toward the close. Lot IV was fed 2.66 pounds of corn meal, 4 pounds of cowpea hay, and 8 pounds of skim milk at the beginning, which was changed to 5.5 pounds of corn meal, 1.5 pounds of chopped cowpea hay, and 26.75 pounds of skim milk toward the close.

These rations were the amounts of feed that each lot received at a single feed, so that the daily ration for one lot of pigs was double the amounts given above. The feeds were valued as follows: Corn meal, $17 per ton; pea hay, $13.50 per ton; wheat meal, $25 per ton; skim milk, 22 cents per 100 pounds; whey, 11 cents per 100 pounds. The results were as follows:

Economy of skim-milk feeding.

Ration.	Number of pigs.	Total gain.	Number of days fed.	Average daily gain.	Total dry matter eaten.	Dry matter per 100 pounds gain.
		Pounds.		*Pounds.*	*Pounds.*	*Pounds.*
Corn meal	3	186	60	1	775	416
Corn meal and skim milk	3	414	60	2.3	1,213	293
Mixed grain, skim milk, and whey	3	402	60	2.2	1,090	271
Corn meal, cowpea hay, and skim milk	2	246	60	2.0	1,017	414

Ration.	Total cost of feed.	Cost of feed per 100 pounds gain.	Net profit.[a]	Slaughter test.	
				Dressed weight.	Intestinal fat.
	Dollars.	*Dollars.*	*Dollars.*	*Per cent.*	*Pounds.*
Corn meal	7.39	3.90	7.69	73.6	13
Corn meal and skim milk	17.61	4.20	12.06	78.5	16
Mixed grain, skim milk, and whey	13.84	3.40	14.89	76.2	16
Corn meal, cowpea hay, and skim milk	12.97	5.20	4.12	77.7	9

[a] Value of manure and cost of care and feed considered.

The pigs were bought on the Knoxville market at 4½ cents per pound and weighed from 130 to 140 pounds at the time of purchase. They were sold at 5½ cents per pound.

The great advantages to be gained by feeding dairy by-products with carbonaceous concentrates are brought out in the results. The pigs on corn meal alone ate less than any others, and although their cost of feed was low they were not so profitable as those fed milk and grain, which ate very much more. An exception to the general rule is seen in Lot IV, which were fed very unprofitably.

With the pigs selling at 5½ cents per pound live weight, the authors estimate that this experiment returned, for the corn fed, 66.7 cents per bushel of 56 pounds, which is said to be 26.7 cents per bushel more than Tennessee farmers usually get for their corn. The feeding value of skim milk in this test was, approximately, 28.3 cents per 100 pounds

During the two years following the above experiment Soule and Fain[a] studied the value of skim milk in a corn-meal ration and in a mixed-meal ration. The pigs of the first year were of Chester White and Berkshire blood, some being Chester grades and others said to be Chester White-Berkshire crosses. They were above the average in quality. Those of the second year were Berkshire grades, below the average of the preceding year. The pigs were confined in pens and fed twice daily. Feeding was carried on through the winter. The first winter "was cool and bracing and uniformly dry;" the second "was raw and damp, with an excessive rainfall, and this no doubt had an influence on the general health of the hogs."

The lots which were used to compare a straight corn-meal ration with a corn-meal and skim-milk ration received, respectively, rations of corn meal only and corn meal and milk in the proportion of 1 to 8 by weight at the start, the milk being decreased toward the close so that the proportion of meal to milk was about 1 to 7.

Corn meal was charged at $28 per ton during the first year and at $19 per ton during the second year. Skim milk was charged at $4 per ton during both years.

The following table shows some of the results of this investigation. The findings of the two years were averaged, from which average these figures are taken:

Economy of skim-milk feeding.

Ration.	Number of pigs.	Total gain.	Average daily gain.	Total feed eaten.	
				Grain.	Milk.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Corn meal	7	119	0.50	489	----------
Corn meal and skim milk	7	309	1.35	481	3,686

Ration.	Feed per 100 pounds gain.		Total cost of feed.	Cost of feed per 100 pounds gain.	Profit per group.[a]
	Grain.	Milk.			
	Pounds.	*Pounds.*	*Dollars.*	*Dollars.*	*Dollars.*
Corn meal	410	----------	5.75	5.80	1.05
Corn meal and skim milk	160	1,190	12.95	4.60	4.96

[a] Value of manure and cost of care not considered.

The favorable results from the feeding of skim milk with corn meal are very noticeable in these results. Although the addition of skim milk added to the cost of the total feed and the feed per 100 pounds gain was accordingly higher, the profit for the pigs on skim milk was $3.91 more than that of those on corn alone.

Value of skim milk in a mixed ration.—As part of the investigation of the years just mentioned, Soule and Fain[a] studied the value of

[a] Vol. XVI, Bul. No. 3, Tennessee Expt. Sta.

skim milk in various proportions with a mixed ration of corn meal and wheat meal or corn meal and soy-bean meal. The proportions of these grains was 1 part of wheat or soy-bean meal to 2 parts of corn meal. The following prices per ton were charged for the feed:

	First year.	Second year.
	Dollars.	*Dollars.*
Corn and wheat meal	29	22
Corn and soy-bean meal	33	25
Corn meal	28	19
Skim milk	4	4

The conditions were those described in the foregoing paragraph. The following table shows some of the results of the averages for the two years as published by the station:

Value of skim milk in a mixed-grain ration.

Ration.	Number of pigs.	Total gain.	Average daily gain.	Total feed eaten.	
				Grain.	Milk.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Grain 1 Milk 3	7	314	1.35	682	2,046
Grain 1 Milk 6	7	306	1.30	590	2,046
Grain 1 Milk 8	7	304	1.30	487	3,039
Grain 1 Milk 9	7	331	1.40	517	4,654
Grain 1 Milk 12	7	320	1.40	436	5,226
Grain 1 Milk 8	[a] 7	307	1.30	491	3,731

Ration.	Feed per 100 pounds gain.		Total cost of feed.	Cost of feed per 100 pounds gain.	Profit per group. [b]
	Grain.	Milk.			
	Pounds.	*Pounds.*	*Dollars.*	*Dollars.*	*Dollars.*
Grain 1 Milk 3	220	650	12.46	4.40	7.63
Grain 1 Milk 6	190	1,160	14.35	5.10	5.27
Grain 1 Milk 8	160	1,220	13.54	4.80	4.13
Grain 1 Milk 9	160	1,410	15.67	5.10	5.62
Grain 1 Milk 12	140	1,640	15.83	5.30	4.77
Grain 1 Milk 8	[a] 160	1,220	14.49	5.10	3.38

[a] The grain to this lot was corn meal 2 parts, soy-bean meal 1 part. That to all the other lots was corn meal 2 parts, wheat meal 1 part.

[b] Value of manure and cost of care not considered.

The most economical ration is seen to be one in which the proportion of grain to skim milk was as 1 to 3. Beyond a certain point, it was found to be expensive to give the pigs a large amount of skim milk. However, all the lots receiving the dairy ration made good gains; the only one of the two years' tests which made an extremely poor showing was that on corn meal alone.

Skim milk compared with nitrogenous concentrates.—In order to compare the value of skim milk as a balance with that of a mixture of gluten and linseed meals Patterson[a] fed two lots of pigs of 6 each at the Maryland Station. Lot I received a ration as follows: Hominy chop, 300 pounds; ground corn fodder (new corn product), 100 pounds; skim milk, 2,400 pounds. Lot II received: Hominy chop, 300 pounds; ground corn fodder, 100 pounds; King gluten meal, 100 pounds; and linseed meal, 200 pounds. The grain was fed as a slop. Results were as follows:

Skim milk compared with nitrogenous concentrates.

Ration.	Average weight at beginning.	Average gain.	Number of days fed.	Average daily gain.	Feed eaten per 100 pounds gain.		Nutritive ratio.
					Grain and fodder.	Milk.	
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*	
Grain, fodder, and milk	66	187	121	1.54	300	1,272	1:3.52
Grain and fodder	57	136	121	1.12	407	.....	1:3.61

This experiment seems to bear out the contention that skim milk has more value as a feed than is indicated by the digestible nutrients it contains. The use of milk effected a saving of practically 25 per cent of grain in the feed required for 100 pounds of gain. The rations fed were identical in nutritive ratio, and they were made up of the same feeds, except that one was balanced with skim milk and the other with gluten and linseed meals. The great difference between the feeding values of the two rations must be ascribed to the effect of skim milk on the digestive system, and it would seem that a ration may be balanced in other ways than by the addition of certain proportions of nutrients with certain fuel values—a "balanced ration" being regarded as the one that gives the best results when fed for a certain purpose.

A comparison of skim milk and green clover in a pig's ration.—At the Maryland Station, Patterson,[a] fed two lots of Duroc Jersey and Berkshire grades of 6 pigs each on rations, one of which was balanced with skim milk and the other included cut green clover instead of milk. The grain was corn-and-cob meal, 8 parts, and 1 part each of gluten meal and linseed meal. The clover was given only in such

[a] Bul. No. 63.

amount as the pigs would eat. It was not possible to get them to eat enough to balance the ration completely. The feeding period lasted one hundred and sixty-five days.

Skim milk compared with green clover for pigs.

Ration.	Average weight at beginning.	Average gain.	Average daily gain.	Feed eaten per 100 pounds gain.			Digestible dry matter per 100 pounds gain.	Nutritive ratio.
				Grain.	Milk.	Clover.		
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	
Grain and skim milk	46.3	207.5	1.26	377	1,470	.....	405	1:4
Grain and clover	47.1	99.30	.60	747	.....	145	555	1:6.6

This experiment does not show profitable results from the feeding of green clover as compared with skim milk. The returns for the green clover are not at all satisfactory, very much less so than the results of other tests that have been made.

Corn meal and a mixture of corn meal and middlings in a skim-milk ration.—Clinton[a] reports the results of four years' experimenting at the Cornell University Experiment Station to study the value of certain proportions of skim milk to grain in the ration and the relative value of corn meal and a mixture of corn meal and wheat middlings in such a ration. In two experiments the best results were obtained when the ratios of grain to milk were as 1:3 and 1:2.5; in the other two the best results were with a ration in which the ratios of grain to milk were as 1:6.7 and 1:6.2. There were 133 hogs fed in these tests. The following table has been compiled from the results, and shows the feed required for 100 pounds gain for the two feeds:

Economy of skim-milk feeding.

Ration.	Number of tests.	Number of pigs.	Feed required for 100 pounds gain.	
			Grain.	Milk.
			Pounds.	*Pounds.*
Corn meal and milk	17	81	273	1,016
Corn meal, middlings, and milk[a]	12	52	223	1,069

[a] The proportion of these feeds was 4:1 in three tests. In the fourth it was not stated.

Grain values of skim milk.—The following figures show the grain values of skim milk as obtained under various methods of feeding at Ottawa.[b] The results are combined in the following table:

[a] Bul. No. 199. [b] Bul. No. 33, Central Experimental Farm.

Grain values of skim milk.

Number of pigs.	Skim milk consumed per head daily.	Milk value of 100 pounds grain.	Kind of grain.	Grain value of 100 pounds milk.
	Pounds.	*Pounds.*		*Pounds.*
4	2	183	Corn	54.64
7	3	183	do	54.64
8	3	354	Barley	28.24
31	3	323	Mixed grain	30.96
4	5.4	538	do	18.69
4	5.41	534	do	18.72
4	13.6	791	Frosted wheat	12.64
5	15.7	699	Mixed grain	14.30
5	15.7	734	do	13.62
2	17.1	882	do	11.33
2	17.14	882	do	11.33
2	23.7	776	do	12.88
4	32.41	834	do	11.99
Average		604		16.55

The average of results obtained by Danish experimenters is a value of about 600 pounds of milk for 100 pounds of grain, but the greater amount of work of this nature in America has shown a higher value for skim milk. The average of nineteen trials in Wisconsin with proportions of milk ranging from 1 to 9 pounds for each pound of grain fed, with hogs of all ages, was that 475 pounds of skim milk were equal to 100 pounds of meal.[a] In Utah[b] Linfield found the value of 100 pounds of milk in terms of grain (that is, the amount of grain replaced by 100 pounds of milk) to be 23.2 and 26.3 pounds, respectively, in two series of experiments. Grisdale[c] values milk at from one-fifth to one-sixth as much as mixed grain. In all experiments the large return where the proportion of milk to grain is small is particularly noteworthy. Milk should never be given to pigs in unlimited amounts except while with the sow, or immediately after weaning, up to the weights of 75 or 100 pounds. At this early age, much grain will disarrange the digestion and best results can be expected from a ration that is largely milk.

Grain required for 100 pounds gain when feeding skim milk and grain as compared with grain alone and milk alone.—The following table is adapted from one compiled by Linfield[d] from the results of various stations for the purpose of showing the cost in grain of feeding rations of grain and skim milk, grain alone, and skim milk alone.

[a] Henry: Feeds and Feeding, p. 572.
[b] Bul. No. 57.
[c] Bul. No. 33. Central Experimental Farm.
[d] Bul. No. 57, Utah Expt. Sta.

Feed per 100 pounds gain.

Station.	Dry matter for 100 pounds gain.		
	Grain and milk.	Grain alone.	Milk alone.
	Pounds.	*Pounds.*	*Pounds.*
Wisconsin	345	455	180
Colorado	298	576	.....
New Hampshire[a]	231	334	.....
Utah[a]	334	421	298
	258	319	285

[a] The results in New Hampshire and the second line of Utah results show estimated digestible dry matter.

These figures show what can be regarded as representative values of these three methods of feeding, and emphatically demonstrate the economy of the grain-and-milk combination. Linfield calls attention to the fact that none of the pigs fed milk alone attained a weight of over 100 pounds, whereas some of those in the other columns reached nearly 300 pounds. It does not always mean profitable feeding for a hog to require a small amount of feed to make a certain gain.

Value of milk at various prices for grain.—Using as a basis the results obtained in the investigations already mentioned, Linfield[a] makes the following estimates of the value of skim milk as a supplementary feed in a ration at various prices for grain:

Value of skim milk for pigs.

Ration.	Number of pigs.	Grain equal to 100 pounds skim milk.	Value of skim milk per 100 pounds when grain is worth, per 100 pounds—						
			40 cents.	50 cents.	60 cents.	70 cents.	80 cents.	90 cents.	$1.
		Pounds.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
Milk and grain	27	23.2	9.3	11.5	13.9	16.2	18.6	20.9	23.2
Milk	11	14.2	5.7	7.1	8.5	9.9	11.4	12.8	14.2

A similar study was made by Lindsey[b] and others from the results at the Hatch Station, except that the figures do not include the results of feeding on milk alone. The averages of their experiments are given in the following table. "Starchy feeds" refer to such substitutes for corn meal as hominy meal, cerealine feed, rye meal, wheat meal, etc.; "other grains" are the nitrogenous feeds, such as wheat bran, gluten meal, linseed meal, etc.:

[a] Bul. No. 57, Utah Expt. Sta. [b] Eleventh An. Rpt., Hatch Expt. Sta.

Value of skim milk for pigs.

Cost of feed—	With dressed pork at 5 cents per lb., skim milk is worth—		With dressed pork at 6 cents per lb., skim milk is worth—		With dressed pork at 7 cents per lb., skim milk is worth—	
	Per quart.	Per 100 pounds.	Per quart.	Per 100 pounds.	Per quart.	Per 100 pounds.
	Cent.	*Cents.*	*Cent.*	*Cents.*	*Cent.*	*Cents.*
With corn meal and other starchy feeds at $15 per ton, "other grains" at $17.50 per ton	0.50	23.07	0.67	30.73	0.83	38.19
With corn meal and other starchy feeds at $17.50 per ton, "other grains" at $20 per ton	.45	20.66	.61	28.14	.78	35.86
With corn meal and other starchy feeds at $20 per ton, "other grains" at $22.50 per ton	.39	18.08	.56	25.82	.78	35.70

Cost of feed when feeding skim milk.—The following shows the cost of feed per 100 pounds of live and dressed weight produced as estimated from the Massachusetts[a] experiments at various prices for grain and milk:

Cost of feed per 100 pounds of growth produced.

Cost of feed—	Cost per 100 pounds live weight.	Cost per 100 pounds dressed weight.
	Dollars.	*Dollars.*
With corn meal at $15 per ton, "other grains" at $17.50 per ton, and milk at ¼ cent per quart	2.78	3.47
With corn meal at $15 per ton, "other grains" at $17.50 per ton, and milk at ½ cent per quart	4.00	4.99
With corn meal at $17.50 per ton, "other grains" at $20 per ton, and milk at ¼ cent per quart	3.04	3.79
With corn meal at $17.50 per ton, "other grains" at $20 per ton, and milk at ½ cent per quart	4.25	5.31
With corn meal at $20 per ton, "other grains" at $22.50 per ton, and milk at cent per quart	3.63	4.53
With corn meal at $20 per ton, "other grains" at $22.50 per ton, and milk at ½ cent per quart	4.51	5.63

The labor cost of feeding.—In experiments in pork production investigators almost invariably disregard the expense of care and labor, estimating that this will be covered by the value of the manure made and the saving in expense of marketing crops. This is always

[a] Eleventh An. Rpt., Hatch Expt. Sta.

more or less of an obstacle in applying the results of experiments to actual farming conditions, for the manure is not always carefully saved on the farm. Linfield,[a] of the Utah Station, studied the labor cost as shown by the experience of some of the creameries in his State that were feeding large numbers of hogs, and states the result of his inquiries as follows:

> One creamery reports that one man would feed 1,000 hogs, clean all the pens each day, and draw the grain feed from the mill 2 miles distant. Another says that one man does all the work of feeding and cleaning out the pens for 500 hogs in five hours each day. The wages paid in each case was about $1 per day.
>
> At both creameries the hogs are purchased when weighing from 50 to 100 pounds each, though some few are heavier. The hogs are crowded from the start, and at most not more than 100 days are required to fit the hogs for market, and in this time 100 to 125 pounds have been added to the live weight of each hog.
>
> By putting all of the above figures together we find that it costs five hours' labor or 50 cents to look after 500 hogs for one day, or $50 to look after 500 hogs for one hundred days. This is 10 cents for 1 hog for one hundred days, or for 100 pounds gain, which gives one-tenth of a cent as the labor cost of producing 1 pound of live weight of hog. It is thus evident from the results of these practical men that when handled in large numbers, as hogs may be at a creamery, the labor is a very small item in growing the hogs. If the value of the gain was reckoned at 4 cents per pound the labor cost of producing the pork was but 2½ per cent of its selling price.

Lest these results be misleading, Linfield calls attention to the fact that the conditions were almost ideal for the greatest economy, the hogs were "short fed," and all feeding appliances and pens were so arranged as to have in view the greatest possible saving of labor. At another creamery, where the hogs were raised on the place and fed until they were fifteen months old and the accommodations were not so good, the cost reported was as large for 300 hogs as the others reported for 1,000 head. It is pointed out that, on the average farm, where the number of animals is much smaller, and milk must usually be hauled back to the farm, the labor cost will be very much greater.

Skim-milk rations for growing pigs.—The Hatch Station[b] recommends the following rations for pigs weighing from 20 to 180 pounds when the feeder has an unlimited supply of skim milk at hand:

Rations for growing pigs.

Weight of pigs.	Rations.
20 to 60 pounds	3 ounces of corn meal to each quart of milk.
60 to 100 pounds	6 ounces of corn meal to each quart of milk.
100 to 180 pounds	8 ounces of corn meal to each quart of milk.

[a] Bul. No. 57. [b] Eleventh An. Rpt.

The following rations may be used where the milk supply is in limited amounts:

Rations for growing pigs.

Weight of pigs.	Rations.
20 to 180 pounds	3 ounces of corn meal, wheat, rye, or hominy meals to each quart of milk, and then gradually increase meal to satisfy appetites.
20 to 60 pounds	Milk at disposal, plus mixture of one-third corn meal, one-third wheat bran, and one-third gluten meal to satisfy appetites.
60 to 100 pounds	Milk at disposal, plus mixture of one-half corn meal, one-fourth wheat bran, and one-fourth gluten meal to satisfy appetites.
100 to 180 pounds	Milk at disposal, plus mixture of two-thirds corn meal, one-sixth wheat bran, and one-sixth gluten meal to satisfy appetites.
20 to 60 pounds	3 ounces of corn meal to each quart of milk, and 4 ounces of gluten feed as a substitute for quart of milk.
60 to 100 pounds	Milk at disposal, and mixture of one-half corn meal and one-half gluten feed to satisfy appetites.
100 to 180 pounds	Milk at disposal, and mixture of two-thirds corn meal and one-third gluten feed to satisfy appetites.

Sweet compared with sour whey.—At the Ontario Agricultural College, Day[a] conducted five experiments to compare the feeding values of sweet and sour whey. Each experiment was preceded by a preliminary period of from one to two weeks and the experiments proper varied in duration from twenty-nine to sixty-four days. In each one as a check a group of pigs was fed on meal only mixed with water. The group receiving whey had it mixed with the grain, and both lots received the same quantity of whey, which was about 2 pounds to each pound of meal. All lots had as much feed as they would eat readily. The sour whey fed in 1897 "was kept in a tank which had not been cleaned since early in the summer of 1896." The meal was a mixture of equal parts of pease, barley, and oats.

The following table shows the amount of grain saved by feeding whey for each experiment and for the average:

Grain saved by feeding sweet and sour whey.

Experiment.	Amount of meal saved by 100 pounds of sweet whey.	Amount of meal saved by 100 pounds of sour whey.
	Pounds.	*Pounds.*
No. 1 (1896)	13.32	13.61
No. 2 (1896)	13.32	13.81
No. 3 (1897)	14.88	7.87
No. 4 (1897)	No test.	10.07
No. 5 (1897)	6.08	9.34
Average	11.90	10.94

[a] An. Rpts., 1896 and 1897.

Whey feeding is often attended with difficulty, as it causes a stiffening of the joints and serious lameness. This condition occurred in the experiments of 1896; and in 1897 the group fed sweet whey in experiment No. 4 was so seriously checked by this trouble that they were left out of the comparison. Day calls particular attention to the fact that the lots receiving sour whey were not at all affected.

If experiment No. 4 is omitted in the preceding table, the average amount of meal saved by 100 pounds of sour whey is 11.15 pounds. The value of whey in pork feeding is, according to these figures, about half that of skim milk.

The following shows the results of six analyses of whey made during these experiments by the chemical department of the Ontario Agricultural College:

Composition of whey.

	Sweet whey.	Sour whey.
	Per cent.	*Per cent.*
Nitrogenous matter	0.920	0.973
Sugar	4.709	.081

Day suggests that the higher percentage of nitrogenous substances in the sour whey was perhaps due to evaporation of the original samples.

PASTURE AND PASTURE SUBSTITUTES.

PASTURE.

Value of pasture with a grain ration.—The Utah Station[a] has devoted considerable study to the effect and value of pasture for pigs that are on a grain ration. The pastures used were made up of mixed grasses and alfalfa. The Utah problem in pork production is defined as the use of "a minimum amount of grain and a maximum amount of alfalfa, milk, and whey, or other cheap foods." The following table shows the results of four seasons' study of this problem, where rations of grain and pasture and grain alone were compared:

Value of pasture with grain.

Ration.	Feed eaten daily.	Total gain.	Average daily gain.	Feed eaten per 100 pounds gain.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Grain and pasture	4.72	247	1.21	385
Grain	4.05	185	.94	430

These results strongly favor the use of pasture when feeding pigs under conditions similar to those that exist in Utah. In every respect the pigs on pasture show better results than those that had no pasture; the total gain per head averaged 33 per cent greater for the

[a] Bul. No. 70.

pigs on pasture than for those on grain alone; the average daily gains were nearly 29 per cent greater, and there was a saving of more than 10 per cent in the feed per 100 pounds gain for the pigs on pasture.

Value of a grain ration with pasture.—The converse of the Utah experiments is shown by two experiments by Morrow and Bone[a] in Oklahoma.

Two lots of 4 pigs each were placed in half-acre alfalfa lots, one being given a full feed of grain and the other receiving none. In eight weeks the lot without grain had gained only 68 pounds, or 17 pounds each, and those having grain gained 324 pounds, or 81 pounds each.

A sow with a litter of 5 pigs was in the same lot with the grain-fed pigs. The sow gained 61 pounds in thirty-five days, when she was removed. Her 5 pigs made a total gain of 146 pounds in the first five weeks and 96 pounds during the succeeding period of three weeks. The grain fed these pigs amounted to only 221 pounds per 100 pounds gain.

Pasture in addition to dairy by-products.—Four tests were made in Utah[b] to determine the value of pasturing pigs that are receiving a ration of grain, milk, and whey. One test was made with pasturing pigs that were receiving milk and whey, but no grain. The ratio of milk to grain by weight was 5:1 at the start and 3:1 at the close in the second and third tests. In the fourth test the grain was limited to one-half the quantity fed the other lots, but all the milk and whey was given that the pigs would take.

The pigs that received the grain and dairy by-product ration were fed in pens.

The following table shows the results for each test and the average of all:

Value of pasture with dairy by-products.

Ration.	Total gain.	Average daily gain.	Feed eaten daily.		Feed per 100 pounds gain.	
			Milk.	Grain.	Milk.	Grain.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Milk[a] and pasture	218	0.69	21.00	.....	3,034	.....
Milk	202	.64	23.54	.....	3,672	.....
Milk, grain, and pasture	350	1.11	9.56	3.34	859	300
Milk and grain	366	1.16	10.71	3.13	921	269
Milk, grain, and pasture	324	1.25	10.11	3.38	805	269
Milk and grain	351	1.35	11.52	3.24	879	238
Milk, grain, and pasture	273	1.05	15.65	1.09	1,479	139
Milk and grain	284	1.10	18.12	1.62	1,837	147
Average with pasture	291	1.03	14.08	2.60	1,544	236
Average without pasture	301	1.06	15.97	2.66	1,827	218

[a] By "milk" is meant both milk and whey.

The results of the first test bear out previous experience with attempts to make pork on pasture without grain, although the gains

[a] An. Rpt. 1898–99, Oklahoma Expt. Sta. [b] Bul. No. 70, Utah Expt. Sta.

given are fairly good and better than might be expected on a pasture containing only a small amount of alfalfa. The addition of skim milk did not prove beneficial in anyway. In the experiments where grain was fed no advantage accrued through the use of pasture, except that the pasture lots consumed nearly 300 pounds less milk per 100 pounds gain than those in pens. At 15 cents per 100 pounds, this means a difference of 45 cents per 100 pounds of pork made. The difference in grain fed was nearly 20 pounds per 100 pounds of pork made in favor of the pen-fed lots.

These results are evidence in support of the idea that the effect of dairy by-products and succulent feed in the ration is similar, and that to get the greatest amount of gain at the least expenditure of feed only one of the supplementary feeds is necessary; that the addition of pasture to a ration which already contains a large amount of dairy by-products is superfluous; and that the only advantage to be gained by such a method of feeding is the exercise obtained by the pigs on pasture.

Pen compared with pasture feeding.—At the Utah Station, Linfield[a] fed six lots of 3 pigs each, in two tests, to study the value of rations composed of grain and milk, grain alone, and milk alone. Both tests were conducted during the summer and fall of the same year. In one test the pigs had the run of a pasture of mixed grasses in which was a large amount of alfalfa. The following table shows a comparison between pen and pasture feeding:

Pen compared with pasture feeding.

Method of feeding.	Average daily gain.	Dry matter per 100 pounds gain.	Estimated digestible dry matter per 100 pounds gain.	Dry matter eaten per day.
Lots fed on milk:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
On pasture	0.7	256	261	1.79
In pen	.65	310	275	2
Lots fed on milk and grain:				
On pasture	1.12	319	261	3.58
In pen	1.17	320	262	3.78
Lots fed on grain:				
On pasture	.81	355	268	4.35
In pen	.51	443	334	2.28

The only pigs that showed better results in pens than on pasture were those on grain and milk. Those receiving grain alone on pasture gave very much larger gains, required less feed per 100 pounds gain, and ate more feed than those receiving grain alone in pens. Linfield suggests that either the exercise or the feed obtained by the run on pasture gave these pigs greater appetite and enabled them to digest a greater amount of feed daily. The fact that neither of

[a] Bul. No. 57.

the other lots showed a marked advantage from pasture might be explained by the skim milk in the ration. It is perhaps a safe proposition that in feeding pigs the best results will follow the use of dairy by-products, roots, or pasture, in connection with grain, but that it is superfluous to combine two of these supplementary feeds, as their action on the digestive system seems to be similar. When attempts are being made to prevent disease, however, the advantage of ample exercise must not be overlooked.

Corn compared with wheat on alfalfa pasture.—At the Nebraska Station,[a] Burnett and Smith placed three lots of 6 pigs each on alfalfa pasture lots one-fourth acre in area. The pigs were Tamworth-Duroc Jersey crossbreds. Lot I was fed ground corn; Lot II, a ration composed of 95 per cent ground corn and 5 per cent dried blood, and Lot III received ground wheat. In addition to the pasture, all the pigs had one week on rape. The experiment lasted forty-two days. The results follow:

Corn compared with wheat on alfalfa pasture.

Ration.	Number of pigs.	Average weight at beginning.	Average weight at close.	Average gain.	Average daily gain.	Average amount feed eaten.	Feed per 100 pounds gain.	Cost per 100 pounds gain.	Profit per lot.[a]
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*	*Dolls.*
Ground corn	6	146	223	77	1.22	308	400	4.00	3.77
Ground corn 95 per cent. Dried blood 5 per cent	6	145	227	82	1.30	308	376	4.04	3.88
Ground wheat	6	147	229	82	1.30	308	376	4.13	3.83

[a] Expense of pasture and labor considered.

The cost of feed in this experiment was, for corn, $1 per hundredweight; wheat, $1.10 per hundredweight, and dried blood, $2.50 per hundredweight. The results are so close together that a slight change in the prices of feed would change the relative rank of these rations. The value of pasture is apparent when these results are compared with those of the experiment at this station with wheat and other grains. (See p. 98.)

Maintaining pigs on pasture alone.—At the Utah Station Foster and Merrill[b] conducted two tests to observe the effect of maintaining pigs on pasture alone.

According to Henry,[c] no station has shown that pigs can be successfully maintained on pasture alone if the test reported from the Utah Station is excepted. The further investigations at this station on this line are therefore of much interest.

In 1898 a comparison was made of mixed pasture and alfalfa pasture. The pigs were about five months old at the beginning of the test, had been fed grain and milk, and were in a very thrifty condition. Both lots had access to running water.

[a] Bul. No. 75. [b] Bul. No. 70. [c] Feeds and Feeding, pp. 578, 579.

The experiment in 1899 was in some ways a continuation of that of 1898. Two lots of pigs were used; both were on alfalfa pasture, but they differed in age. Lot I consisted of 3 pigs about four months old, and Lot II of 3 pigs about seven months old and nearly twice as heavy as those in Lot I. The following table gives the results of the experiments:

Pigs on pasture without grain or milk.

Ration.	Number of pigs.	Total weight at beginning.	Total weight at close.	Total gain.	Number of days fed.	Average daily gain.
1898.		*Pounds.*	*Pounds.*	*Pounds.*		*Pound.*
Lot I. Mixed pasture		251	321	70	125	0.189
Lot II. Alfalfa pasture		284	280	[a]4	109	.0122
1899.						
Lot I. Alfalfa pasture	3	165	188	23	129	.059
Lot II. Alfalfa pasture	3	330	322	[a]8	110	.024

[a] Loss.

These experiments do not change one's opinion regarding the value of pasture alone for pigs. The two lots gained in weight—one on mixed pasture and the other on alfalfa pasture. The effect of this method of feeding on the appearance of the pigs was very marked; in the 1898 test this was particularly commented upon. "The plump rounded forms gave place to large coarse frames and large stomachs. At the end of the experiment they looked very much larger than at the beginning, but the scales failed to show any gains. What is said above would also apply to the mixed pasture set, only in that case the eye was not so badly deceived—small gains were made."

In 1899 pigs that were receiving small amounts of feed, either milk or grain in addition to pasture, were found to have made gains very nearly in proportion to the amount of extra feed given, which Foster and Merrill regard as evidence that the pasture supplied enough feed for maintenance only.

GREEN SUBSTITUTES FOR PASTURE.

Pasturing on rape.—At the Utah Station Foster and Merrill[a] pastured 6 pigs on a plot of rape that had been seeded August 11, after having been irrigated and plowed. The pigs were hurdled in pens 16 feet square and without shelter from rain or snow. They received a ration of 1 pound daily of a mixture of equal parts of bran and chopped wheat.

At the Canada Central Experimental Farm, Grisdale[b] pastured 6 pigs on a plot three-sixteenths acre in extent that had been drilled to rape, the drills being 30 inches apart. These pigs received a daily

[a] Bul. No. 70. [b] An. Rpt., 1900.

grain ration of 1 pound per head at the beginning, which was increased to 5 pounds at the close. At the Alabama Station, Duggar[a] hurdled pigs, which had been weaned three weeks, on rape drilled on sandy upland the previous October. They received about a half ration of corn meal in addition.

The results are as follows:

Pasturing on rape.

Where fed.	Number of pigs.	Total weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Grain eaten.	Grain per 100 pounds gain.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
Utah	6	296	60	49	0.204	294	490
Canada	6	358	869	114	1.27	2,067	238
Alabama	4	130	181	81	.56	524	290

At the close of the Alabama test, the pigs were placed on second-growth rape for three weeks. They grazed one-sixth acre, eating 168 pounds corn meal and making a gain of 82 pounds, which was an average daily gain of 0.98 pound, at a cost of 205 pounds meal for 100 pounds gain. Assuming that 500 pounds of grain alone are required for 100 pounds gain, Duggar[a] estimates the amount of the pork produced per acre from the first and second growth rape together at 512 pounds, worth at that time $20.48.

Seven shoats, averaging 41 pounds in weight, were on rape at the same station for four weeks during the late spring. They received some corn meal in addition. During the first two weeks the rape was fed to the pigs in the pens; during the remainder of the time they were hurdled. They ate 318 pounds of corn meal. The total gain in weight for the four weeks was 103 pounds, an average daily gain of 0.53 pound, 310 pounds of grain and 4,050 square feet of rape being required to produce 100 pounds of gain.

Rape compared with clover.—The Wisconsin Station[b] has reported two experiments comparing rape and clover as pasturage for hogs. In the first, 20 purebred or high-grade Poland China pigs between five and six months of age were used. Lot I was hurdled on rape, had access to water, and had the run of a blue-grass lot. Their grain feed was a mixture of 2 parts of corn meal and 1 part shorts twice daily as slop. Lot II was on a 10-acre lot of second-growth clover, and received the same grain ration as Lot I. In the second experiment the pigs used were purebred and high-grade Berkshires and Poland Chinas. Their grain ration was the same mixture as that used in the first experiment, mixed into a thick slop. Lot I was hurdled on

[a] Bul. No. 122. [b] Sixteenth and Seventeenth An. Rpts.

rape; Lot II had the run of an 8-acre field of second-growth clover. The results were as follows:

Rape compared with clover.

Ration.	Number of pigs.	Total weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Grain eaten.	Grain per 100 pounds of gain.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
Grain and rape	20	2,111	1,043	63	0.87	4,083.75	392
Grain and rape	21	2,139	1,492	56	1.27	4,965	333
Average							362
Grain and clover	20	2,091	941	63	.78	4,083.75	434
Grain and clover	21	2,136	1,435	56	1.22	4,965	346
Average							390

These experiments give rape a greater value for pigs than clover pasture. Rape has an advantage of over 7 per cent in grain required per 100 pounds of gain.

The influence of rape on grain eaten.—At the Wisconsin Station Carlyle[a] fed two lots of pigs—one lot hurdled on rape pasture and the other fed in a roomy yard without any kind of green feed. Both lots received the same grain ration, which was a mixture of equal parts of corn meal and shorts made into a slop immediately before feeding, and had coal ashes at all times. The experiment began August 4, when the rape was about 20 inches high. The pigs used were about four months old at the beginning of the experiment, and represented the Poland China, Berkshire, and Yorkshire breeds. The following is a summary of the results:

Value of rape with grain.

Ration.	Total weight at beginning.	Total weight at close.	Grain eaten.	Total gain.	Average gain.	Average daily gain first six weeks.	Average daily gain second six weeks.	Grain per 100 pounds gain.	Cost of grain per 100 pounds
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pound.*	*Pounds.*	*Pounds.*	*Dollars.*
Lot I, without rape	1,017	2,211	5,642	1,194	70.2	0.71	1.08	437	3.78
Lot II, with rape	1,001	2,412	5,920	1,411	83	.88	1.23	420	3.36

Exclusive rape feeding.—At the Wisconsin Station Carlyle[b] fed two lots of pigs on rape alone for two weeks. Two lots of 18 pigs each were taken from rations composed of grain exclusively, grain and clover, and grain and rape. They were given nothing but rape. They fed nearly all day, appeared contented, and scoured but little, but 25 of

[a] Eighteenth An. Rpt. [b] Seventeenth An. Rpt.

the 36 lost in weight during the two weeks. They were on rape, and only 4 made gains. The total loss on 36 pigs was 60 pounds, or at the rate of $1\frac{2}{3}$ pounds per pig. The 6 pigs that had been on an exclusive grain diet lost 18 pounds, or 3 pounds each. The 8 pigs that had been on grain and clover lost 19 pounds, an average of nearly $2\frac{1}{3}$ pounds each, and the 22 pigs that were taken from a grain and rape diet lost 33 pounds, or $1\frac{1}{2}$ pounds each.

Soiling.—The Utah Station[a] reports the results of seven tests of the value of green feed to pigs in pens and yards on full grain and one-fourth grain rations. In four tests the pigs were in pens and in three they were in open yards. The green feed was mainly alfalfa, but some waste garden products were also fed.

During the first two years of these tests, embracing four experiments, the dry matter in the grass was estimated and included in the figures for feed eaten; but in the last three tests only the actual weight of grain fed was taken into account. The following table shows a summary of the results:

Value of soiling pigs on grass.

Ration.	Number of tests.	Average daily gain.	Feed eaten daily.	Feed per 100 pounds gain.
Average of all:		*Pounds.*	*Pounds.*	*Pounds.*
Full grain	7	1.04	4.42	424
Full grain and grass	7	1.13	4.74	414
One-fourth grain and grass	3	.36	2.23	659
Average of pens:				
Full grain	4	.94	4.05	442
Full grain and grass	4	1.17	4.75	402

These results show a considerable advantage in daily gains for the pigs that were soiled and a similar saving in feed. The pigs in pens show a very marked advantage for soiling. There was an average daily gain of 0.23 pound more for the soiled pigs than for those on grain alone, and the feed required for 100 pounds gain was nearly 10 per cent less. It is suggested that these good results were due as much to the healthful action of such feed on the digestive system as to their nutrient content.

The Ontario Agricultural College[b] conducted an experiment to compare pasturing on such feeds as vetches and rape with their feeding in pens. Disregarding the item of labor, these results show that soiling is very economical. The average daily consumption of feed by pigs in the pens was approximately 4 pounds of green feed and

[a] Bul. No. 70. See page 93 for explanation of "partial" and "full" grain rations.
[b] An. Rpt., 1901.

4⅓ pounds of meal. This experiment was part of a breed test, and generally the best pigs were in the outside lots. Yet the meal required for 100 pounds gain was, for all breeds, 510 pounds with the outside lots and 414 for those in the pens on grain and green feed. At the close of the experiment the pigs were sold, and the packer's report showed nothing unfavorable to the method of feeding. The bacon produced was firm and of good quality in other ways. The pigs that were soiled required twice as much time for attention and feeding as those outside.

Purslane.—Plumb[a] reports a trial in Indiana with two Chester White sows confined in small pens and fed for twenty-one days a mixture of equal parts shorts and hominy meal with all the purslane they would eat. Purslane was not eaten with the relish that was expected, but the pigs made fairly good gains at a cost of 2.2 cents per pound.

Grazing chufas.—Duggar[b] hurdled 9 Berkshire pigs from November 19 to December 17 on chufas, with some grain, and a mixture of corn meal and cowpea meal in addition. They gained 121 pounds, grazed 7,986 square feet of chufas, and ate 262 pounds of grain, thus requiring only 234 pounds of grain for 100 pounds gain. With the usual allowances for the gain due to the grain fed, the return per acre for the chufas, estimating pork at 3½ cents per pound, was $13.09.

Grazing peanuts, chufas, and soy beans.—At the Arkansas Station, Bennett[c] fed four lots of half-bred Berkshire pigs to compare the grazing values of these three crops with pen feeding on corn. The soil on which the crops were grown was a sandy loam with an estimated capacity of 30 bushels of corn per acre. The crops named were planted in rows 3 feet apart—the peanuts 14 inches apart in the rows, the chufas[d] 12 inches apart in the rows, and the soy beans drilled. The stand was estimated at 87 per cent for the peanuts, 75 per cent for the chufas, and only good for the soy beans. The corn was fed dry on the ear, and the grazing was done by using hurdles. The feeding

[a] Bul. No. 82.

[b] Bul. No. 122, Alabama Expt. Sta.

[c] Bul. No. 54.

[d] Chufas are coarse plants belonging to the sedge family. Two species are used in the manner here mentioned—*Cyperus rotundus* and *C. esculentus*. According to Gray, *C. rotundus* is found in sandy fields from Virginia to Florida and Texas, and is occasionally met with in the neighborhood of Philadelphia and New York City. *C. esculentus* is found in low grounds, along rivers, etc., from New Brunswick to Florida and west to Minnesota and Texas. This is the species more commonly used as feed for hogs.

These plants form small tubers which enable them to spread rapidly and form a thick, matted growth, each tuber being capable of producing a plant. The tubers are relished by hogs, but the plants are of questionable value, as it is almost impossible to eradicate them when once established, especially in sandy soils. Botanists do not advise planting them in soil that can be used for any other purpose.

lasted forty-six days, except for the soy beans, which gave out sooner than expected. The results were as follows:

Peanuts, chufas, and soy beans compared with corn.

Kind of feed.	Number of pigs.	Average weight at beginning.	Total gain.	Average daily gain.
		Pounds.	*Pounds.*	*Pound.*
Peanuts	4	116.5	104.5	0.57
Chufas	4	121.3	66	.35
Soy beans	3	124.75	[a]22.75	[a].24
Corn	3	139	112.3	.81

[a] Thirty-two days.

The areas of peanuts and chufas grazed were one-twelfth acre and one-ninth acre, respectively. To produce 112.3 pounds of pork with the corn-fed lot 7.6 bushels of corn were eaten. From these data the yield of pork per acre was estimated as follows:[a] Peanuts, 1,252 pounds; chufas, 592 pounds; corn, 436 pounds, estimating the corn yield at 30 bushels per acre.

The quality of the pork from pigs grazed on chufas and soy beans was about the same as that from corn-fed pigs; the peanut-fed lot produced a soft, oily quality of fat, but no deleterious results could be detected in cooking.

In the following two years Bennett[b] grazed pigs on peanuts and chufas, the results being noted below. In addition to the study of the feeding value of these plants, their effect on the quality of the pork was studied. When hogs are grazed on peanuts or chufas the lard has quite a low melting point; and, as nearly all such feeding is conducted in the Southern States, this condition gives rise to considerable trouble during the summer months. To obviate this difficulty the common practice of farmers is to use corn in finishing hogs that have had peanuts as the principal component of the ration. The results of the study of the effects of these feeds on the quality of pork are presented elsewhere in this bulletin.

Bennett's feeding results in 1899 and 1900 follow:

In 1899 Lot I grazed a crop that was alternately three rows of peanuts and one of chufas; Lot II grazed peanuts; Lot III grazed chufas; Lot IV grazed chufas; Lot V grazed as Lot I. The grazing lasted sixty days, except for Lots IV and V, which grazed ninety days. Lots III, IV, and V had no finishing period on corn. Two pigs were slaughtered in both of the first two lots at the expiration of the grazing period, the melting point of the fat determined, and the remaining pigs put on a full feed of corn. At intervals of two weeks 2 more

[a] Soy beans not estimated. [b] Bul. No. 65, Arkansas Expt. Sta.

pigs were slaughtered and the melting point of the fat determined, continuing in this manner until all the pigs were slaughtered, so that the last pigs to be slaughtered had been on corn eight weeks.

The pigs used in the 1899 experiment were natives, not over one-fourth of improved blood. They were from ten to twenty months old and averaged about 115 pounds in weight.

In 1900 the feeding was as follows: Lot I grazed on a field of alternate rows of peanuts and chufas for seventy-five days, receiving some corn in addition. Lot II grazed a field of alternate rows of peanuts and chufas for fifty days, and for twenty-five days received a quantity of corn equivalent to that fed the above lot. Lot III grazed peanuts for seventy-five days and had corn as Lot I. Lot IV grazed peanuts as above for fifty days and had corn for twenty-five days as the preceding lots. Lot V grazed on peanuts and had corn at the same time for seventy-five days. The pigs of this lot were purebred Berkshires, and were used to determine the effect of improved blood on the melting point of lard.

The quality of these pigs was somewhat higher than in the experiment of 1899. The pigs of Lots I to IV were from eight to twelve months old at the beginning; the purebred pigs were from six to eight months old.

The gains of the pigs, while incidental to the main purpose of the experiment, are of much interest. Those for 1899 are as follows:

Comparative gains in feeding pigs on peanuts, chufas, and corn.

Lot.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.
		Pounds.	*Pounds.*		*Pounds.*
I	10	116.7	981	60	1.63
II	10	116.2	996	60	1.66
III	4	111.5	332	60	1.38
IV	2	115.5	246	90	1.37
V	2	116.5	266	90	1.47

The following gains were made during 1900:

Comparative gains in feeding pigs on peanuts, chufas, and corn.

Lot.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.
		Pounds.	*Pounds.*		*Pounds.*
I	4	99.5	518	75	1.72
II	4	95	482	75	1.60
III	4	96.25	535	75	1.78
IV	4	95	510	75	1.70
V	6	96	717	75	1.59

Grazing peanuts.—At the Alabama Station, Duggar[a] grazed 6 Poland China pigs on peanuts, with some corn in addition. The lot made a

[a] Bul. No. 93.

gain of 380.7 pounds in six weeks on an area of about one-sixth acre and ate 373 pounds of corn. Estimating corn at 40 cents per bushel and pork at 3 cents per pound this is a return of $18.34 per acre for peanuts from this method of feeding, somewhat less than the Arkansas experiment previously mentioned.

On a portion of the field which was not pastured the peanuts were dug and yielded at the rate of 62.6 bushels (1,565 pounds) of dry nuts per acre. From this the total feed required to produce 100 pounds gain was estimated as 140 pounds of peanuts and 190 pounds of corn—a total of 330 pounds of concentrates, with vines eaten not estimated.

Duggar estimates the value of the return from peanuts in pork at $18 per acre, and states that the same land with the same fertilizers, would not produce over 200 pounds of lint cotton per acre, which would be worth $10 or $12, with cotton at 5 or 6 cents per pound, while the expense of cultivating the cotton would be much greater.

In a later experiment Duggar[a] penned a litter of 9-weeks-old pigs on a two-thirds stand of Spanish peanuts just after weaning. They were on this pasture from November 4 to December 23, and ate 162 pounds of corn meal for 100 pounds gain in addition to grazing about five-sixths of an acre of peanuts. At 4 cents per pound for pork, and making allowances for the grain eaten, the return per acre for the peanuts was $10.04.

In another test[a] a sow and her litter of 9 pigs were fed from September 30 to November 4 on corn meal, skim milk, and Spanish peanuts from one-fourth acre of land. They ate 355 pounds of corn meal and 921 pounds of skim milk. The sow and pigs gained a total of 236 pounds. At 4 cents per pound for pork, valuing corn meal at $1 per 100 pounds and skim milk at 25 cents per 100 pounds and estimating 325 pounds of skim milk to be worth 100 pounds corn meal, the return per acre for the peanuts was $17.28.

In another test[a] 7 shoats, averaging nearly 100 pounds, were penned on Spanish peanuts from October 11 to November 2 and fed some corn meal. They made a total gain of 225 pounds, eating 286 pounds of corn meal and grazing the peanuts on 0.47 acre, requiring only 127 pounds of corn meal for 100 pounds gain. With the usual allowances, the return per acre for the peanuts in this test was $18.02.

In another test[a] 7 shoats were taken from corn meal, cowpea meal, and sorghum and placed on Spanish peanuts and corn meal for four weeks. They ate 333 pounds of corn meal and grazed 10,593 square feet of peanuts, making a gain of 121 pounds, which was at a cost of 273 pounds grain for 100 pounds gain. The value per acre of the peanut pasture was estimated, by the usual method, at $9.

Some of these pigs were continued by hurdling on peanut pasture and were given some grain in addition for five weeks longer. In this period the return per acre for the peanuts was estimated at $9.88.

[a] Bul. No. 122, Alabama Expt. Sta.

In another test[a] a litter of 7 Poland China pigs, averaging 28 pounds in weight, were hurdled on Spanish peanuts just after weaning. The pasturing continued six weeks and no grain was fed. The total gain was 157 pounds, an average daily gain of 0.53 pound. The area grazed was 13,887 square feet, and the return per acre, with pork at 4 cents per pound, was $20.12.

Peanut pasture compared with corn meal.—The Alabama Station[a] fed one lot of pigs on a peanut field which was a poor stand, giving some corn meal additional; another lot had nothing but the peanut pasture, and a third lot corn meal only. There were 3 pigs in each lot, and they were of rather ordinary feeding qualities. In four weeks the lot on peanuts and corn meal gained 38.6 pounds, those on peanuts alone gained 21.1 pounds, and those on corn meal lost 5.1 pounds. The lot on peanuts and corn meal ate 206 pounds of corn per 100 pounds gain and grazed 2,025 square feet planted in peanuts. "This is at the rate of 840 pounds of growth from 1 acre of peanuts (with less than half a stand) and 1,710 pounds (35.6 bushels) of corn meal. With pork at 3 cents per pound and corn meal at 40 cents per bushel of 48 pounds, this is a gross return of $25.20 and a net return (after subtracting the value of the meal) of $10.94 per acre of peanuts."

The pigs on peanuts only "pastured an area of 3,517 square feet, and the gain made was 21.1 pounds, which is at the rate of 261 pounds of pork per acre. At 3 cents per pound gross for pork, this gives a value of $7.83 to the acre of peanuts on which there was only half a stand of plants."

Duggar estimates the value of peanuts in pork production at $12 to $20 per acre, the higher returns being made where corn meal supplements the peanut pasture.

Peanuts and chufas compared with grain.—Duggar[b] fed four lots of 3 pigs each for eighteen days to compare the values of peanut and chufa pasture with grain alone. Lot I grazed Spanish peanuts and had a half ration of a mixture, by weight, of corn meal 2 parts and cowpea meal 1 part; Lot II grazed Spanish peanuts without grain; Lot III grazed chufas, with the same half grain ration as Lot I; Lot IV was fed in a bare lot and given all the mixture fed Lot I that the pigs would eat up clean. The following table shows the results:

Peanut and chufa pasture compared with grain.

Area grazed and ration.	Average weight at beginning.	Number of pigs.	Number of days fed.	Total gain.	Average daily gain.
	Pounds.			*Pounds.*	*Pounds.*
Spanish peanuts grazed, one-half grain ration	121	3	18	81	1.50
Spanish peanuts grazed	85	3	18	22	.41
Chufas grazed, one-half grain ration	106	3	18	79	1.46
Full grain ration	131	3	18	71	1.31

[a] Bul. No. 93, Alabama Expt. Sta.
[b] Bul. No. 122, Alabama Expt. Sta.

Peanut and chufa pasture compared with grain.—Continued.

Area grazed and ration.	Total feed eaten.		Grain per 100 pounds gain.	Pasturage on 1 acre for a 100-pound shoat.
	Area grazed.	Grain eaten.		
	Sq. feet.	*Pounds.*	*Pounds.*	*Days.*
Spanish peanuts grazed, one-half grain ration	8,344	152	188	850
Spanish peanuts grazed	12,448			463
Chufas grazed, one-half grain ration	7,937	152	192	827
Full grain ration		304	431	

This experiment shows the best returns when grain was fed with these crops. Grazing peanuts alone was very unsatisfactory. The return per acre of peanuts and chufas, with pork at 4 cents per pound, was estimated, where grain was fed, at $9.56 and $9.62, respectively. The pigs on peanut pasture alone returned only $3.03 per acre for the crop. Those on pasture with grain made much more rapid and economical gains than those on grain only.

The last column of the table is especially interesting. With a small amount of grain it is evident that pasture will be available for a much longer period than when no grain is fed.

Grazing sorghum and cowpeas.—Duggar[a] fed four lots of 3 pigs each for five weeks to compare the value of sorghum and cowpea pasture with a grain ration. Lot I was hurdled on drilled sorghum which was in the dough and ripening stages and received a half grain ration of a mixture, by weight, of corn meal 2 parts and cowpea meal 1 part. Lot II was placed in a pen in which sorghum was growing and had, in addition, enough ripe Spanish peanuts to constitute a half ration of peanuts. Lot III was hurdled on drilled Whip-poor-will cowpeas on which part of the pods were ripe and received no grain. Lot IV was confined in a bare pen and given the grain mixture given Lot I in such amount as the pigs would eat up clean. The following table shows the results:

Grazing pigs on sorghum and cowpeas.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Total feed eaten.		Grain per 100 pounds gain.
						Area grazed.	Grain eaten.	
		Pounds.	*Pounds.*		*Pounds.*	*Sq. feet.*	*Pounds.*	*Pounds.*
Grain Grazed sorghum	3	59	75	35	0.71	4,872	244	328
Spanish peanuts Grazed sorghum	3	59	54	35	.51	4,872		
Grazed ripe cowpeas	3	57	51	35	.48	17,964		
Grain	3	64	124	35	1.18		464	374

[a] Bul. No. 122, Alabama Expt. Sta.

These results are not very satisfactory for grazing on sorghum or on cowpeas without a supplementary grain ration. The waste of feed in the cowpea lot was very great, large numbers of the ripe pease falling to the ground and sprouting. Previous work at the Alabama Station has shown more satisfactory results when grain was fed in conjunction with the cowpea pasture.

Duggar[a] notes another experiment with sorghum grazing, in which there was a large waste of feed, although grain was fed. Seven shoats were on the sorghum from June 24 to September 2, 1899, and received at the same time about 1½ pounds per head daily of a mixture of equal parts, by weight, of cowpea meal and corn meal. The pigs grazed 15,374 square feet of sorghum and 8,380 square feet of second-growth sorghum. They ate 812 pounds of grain, or 360 pounds of grain per 100 pounds of gain. Making allowances for the value of the grain fed, the return per acre of sorghum, with pork at 4 cents per pound, was estimated at $7.80. The second-growth sorghum produced only about one-half as much feed as the first growth. Large quantities of the sorghum were trampled under foot, and when some of it was cut and carried to the pigs a given area lasted much longer than when they were turned in to graze. Duggar suggests that when labor is cheap and abundant or a corn harvester is available soiling sorghum will be the more profitable method of feeding.

Cowpea pasture with corn.—Duggar[b] fed 6 Essex shoats from the same litter to investigate the pasture value of cowpeas. Lot I received corn only. Lot II was hurdled on cowpeas that were about half matured at the beginning of the experiment. The field tested 13.2 bushels per acre of peas, on an unpastured portion. Both lots received hard-wood ashes and salt. The results were as follows:

Cowpea pasture and corn compared with corn alone.

Kind of feed.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Corn eaten.	Corn per 100 pounds gain.
		Pounds.	*Pounds.*		*Pound.*	*Pounds.*	*Pounds.*
Corn alone	3	50.9	45.2	42	0.36	263.8	586
Cowpea pasture and corn	3	49.4	122.0	42	.97	374.0	307

The pigs were pastured on an area of 7,280 square feet, or about one-sixth of an acre. Valuing pork at 3 cents per pound and corn at 40 cents per bushel, the return for cowpeas per acre is $10.65, not including the value of the manure made. By pasturing, 277 pounds of corn were saved per 100 pounds gain, and therefore an acre of cowpeas would replace 1,662 pounds of corn, using this test as a basis.

The Maryland Station[c] fed a number of pigs on cowpea pasture and concluded that cowpeas are well adapted to pigs about three

[a] Bul. No. 122, Alabama Expt. Sta. [b] Bul. No. 93, Alabama Expt. Sta. [c] Bul. No. 63.

months old. The older pigs that had been highly fed and had always been kept in a pen evidently had lost their rustling ability and did not thrive so well on cowpeas.

PUMPKINS AND APPLES.

Feeding pumpkins raw and cooked.—At Ottawa, Grisdale[a] fed pumpkins to pigs in considerable numbers. A field was specially prepared, the seed being planted in hills 8 feet apart each way. The yield was about 9 tons per acre and the cost 90 cents per ton. In feeding one lot received raw pumpkins and grain (a meal mixture of one-half corn meal and one-half a mixture of equal parts of oats, peas, and barley). The other lot received cooked pumpkins and the same meal mixture.

At the Oregon Station, French[b] took 6 Berkshires, eight months old, from a stubble field where they had been for six weeks and placed them on a ration of pumpkins and shorts. The pumpkins were the common yellow field variety, and were prepared by cutting up, removing the seed, and cooking or steaming, after which shorts were mixed with them.

At the New Hampshire Station, Burkett[c] fed pigs to compare cooked and raw pumpkins. Lot I, consisting of 3 pigs, received skim milk, corn meal, and cooked pumpkins; Lot II, consisting of 3 pigs, received milk, corn meal, and raw pumpkins. The following table shows the result of these experiments:

Value of pumpkins as feed for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed eaten.			Feed per 100 pounds gain.			Cost per 100 lbs. gain.
						Grain.	Milk.	Pumpkins.	Grain.	Milk.	Pumpkins.	
Ottawa:		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*
Raw pumpkins	----	-------	745	107	------	1,981	------	2,090	267	------	281	3.08
Cooked pumpkins	----	-------	706	99	------	1,602	------	7,500	227	------	1,062	2.96
Oregon:												
Cooked pumpkins	6	171.5	499	-----	1.49	924	------	7,523	185	------	1,508	2.99
New Hampshire:												
Raw pumpkins	3	142	170	25	2.26	514	630	1,348	302	370	793	3.31
Cooked pumpkins	3	138.6	166	25	2.21	514	630	742	309	379	447	3.32

Averaging these results, the raw pumpkins rations show 273 pounds of grain and 376 pounds of pumpkins for each 100 pounds of gain, and the cooked pumpkins rations, 222 pounds of grain and 1,150 pounds of pumpkins for each 100 pounds of gain.

[a] An. Rpt., 1900, Central Experimental Farm. [b] Bul. No. 54. [c] Bul. No. 66.

Raw pumpkins alone.—Burkett[a] fed one lot of hogs on a ration of uncooked pumpkins with no other feed but skim milk with the following results:

Pigs	number	3	
Average weight at beginning	pounds	141	
Total gain	do	84	
Days fed	number	25	
Average daily gain	pounds	1.12	
Milk consumed	do	630	
Pumpkins	pounds	3,798	
Milk per 100 pounds gain	do	750	
Pumpkins per 100 pounds gain	pounds	4,520	
Cost of feed per 100 pounds gain	dollars	2.39	

Feeding pumpkins and apples.—At the same time with the test outlined in the preceding paragraph, Burkett fed a lot of 3 pigs on a ration of apples and pumpkins, half and half, cooked. The pumpkins in all the New Hampshire experiments were raised at a cost of 40 cents per ton; the apples were common cider apples, or windfalls, and were valued at 10 cents per bushel.[b] The results are as follows:

Pigs	number	3	
Average weight at beginning, pounds		140	
Total gain	pounds	116	
Days fed	number	25	
Average daily gain	pounds	1.54	
Milk consumed	do	630	
Pumpkins and apples	pounds	3,762	
Milk per 100 pounds gain	do	545	
Pumpkins and apples 100 pounds gain	pounds	3,246	
Cost of feed 100 pounds gain, dollars		4.65	

The higher cost of gain in this test is attributed to the apples, and it is questioned whether it pays to feed them at a cost equal to or exceeding 10 cents per bushel.

ROOTS AND TUBERS.

Feeding roots to live stock is comparatively recent in the United States. Corn, with hay and ensilage, has been the principal maintenance during the winter months when pasture was not available. In hog feeding it is safe to say that, until very recent years, almost the only substitutes for pasture were pumpkins, artichokes, and clover or alfalfa hay in certain sections. In England and Canada, however, much dependence is placed on roots, and, while we may never reach the point in this country generally of fattening animals almost entirely on a root diet, the peculiar advantages to be gained by them, their great palatability, and the good effect on the health and thrift of the animal commend roots to the stockman.

A number of experiments have been reported recently on feeding roots to hogs.

At the Indiana Station, Plumb and Van Norman[c] conducted two experiments to compare a ration composed solely of grain with one

[a] Bul. No. 66, New Hampshire Expt. Sta.

[b] New Hampshire has no legal weight per bushel for apples, and this bulletin did not state the weight used. The legal weight in other States varies from 44 to 50 pounds.

[c] Buls. Nos. 79 and 82.

where roots were added. In both experiments the grain ration was 1 part corn meal, 2 parts shorts, fed as slop. No drink other than water was given. In the first experiment mangels were fed; in the second the roots were sugar beets sliced and fed in the slop, and they were relished more than the mangels.

At the Ontario Agricultural College, Day[a] fed four lots of pigs in pens as follows:

Lots I and II were made up of 4 grade Yorkshire pigs each from the same litter, about seven weeks old; Lots III and IV contained 5 grade Yorkshire pigs each from the same litter, about 9 weeks old. Lot I received barley and middlings; Lot II received barley and middlings with an equal weight of raw pulped mangels; Lot III received corn and middlings; Lot IV received corn and middlings with an equal weight of raw pulped mangels. The proportion of grain to middlings was 1:2 in all lots at the beginning of the experiment, and was gradually changed as the pigs increased in weight and age until it was 2:1 toward the close.

At the Utah Station, Foster and Merrill[b] conducted two experiments to compare a ration of bran and sugar beets with rations of corn meal, ground wheat, and corn meal and peas. In the first experiment Lot I received corn meal, Lot II received ground wheat, and Lot III received sugar beets with a one-third ration of bran. In the second experiment Lot I received a mixture of equal parts of corn meal and ground peas, Lots II and III being fed as in the first test. The pigs were fed in covered pens, and were given all they would eat. There were 3 in each lot.

At the Montana Station, Shaw[c] fed one lot of hogs on grain only and another on the same grain ration with sugar beets added. The following table shows the results of these experiments:

Value of roots as feed for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Total feed eaten.		Feed per 100 pounds gain.		
						Grain.	Roots.	Grain-fed lots.	Grain-and-root fed lots.	
									Grain.	Roots.
Indiana:		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Grain	6	46	443	77	0.96	1,643	.....	371	.....	.....
Grain and roots	6	44	356	77	.77	1,320	514	.....	371	145
Grain	4	60	444	98	1.13	1,697	.....	382	.....	.....
Grain and roots	4	60	382	98	.77	1,186	1,568	.....	310	410
Ontario Agricultural College:[d]										
Grain	4	42	501	196	.64	.....	.....	439	.....	.....
Grain and roots	4	42	672	196	.86	.....	.....	.....	380	.....
Grain	5	55	664	196	.68	.....	.....	455	.....	.....
Grain and roots	5	55	744	196	.76	.....	.....	.....	404	.....

[a] An. Rpt., 1901.
[b] Bul. No. 70.
[c] Bul. No. 27.
[d] The grain per 100 pounds gain in the Ontario results is dry matter.

Value of roots as feed for pigs—Continued.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Total feed eaten.		Feed per 100 pounds gain.		
						Grain.	Roots.	Grain-fed lots.	Grain-and-root fed lots.	
									Grain.	Roots.
Utah:		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Corn meal	3	97	229	91	.85	1,279	.....	558	.....	.....
Ground wheat	3	97	324	91	1.2	1,505	.....	464	.....	.....
Bran and roots	3	97	167	91	.62	471	2,761	.....	282	1,653
Corn meal and pease	3	87	410	122	1.12	1,672	.....	407	.....	.....
Ground wheat	3	86	330	122	.90	1,330	.....	403	.....	.....
Bran and roots	3	89	258	122	.70	880	[a] 1,771	.....	341	686
Montana:										
Grain	7	111	557	66	1.20	2,967	.....	532	.....	.....
Grain and roots	7	115	576	66	1.26	2,497	819	.....	426	142
Average	.....	.....	.....	.....	.....	.....	.....	442	359	427

[a] Includes 111 pounds of potatoes.

In the experiments tabulated here roots were fed in seven tests to 32 pigs, and in comparison grain was fed in nine tests to 38 pigs, making a total of sixteen lots and 70 pigs. In six of the seven tests where roots were fed there was a saving of grain. In one instance (in Indiana) nothing was gained by feeding roots. The average of feed per 100 pounds gain shows that feeding 427 pounds of roots saved 83 pounds of grain, or 19 per cent, which is a very high value for roots.

This feature of root feeding has previously been remarked upon in this bulletin. Attention is called to it in nearly every instance where experimenters have fed roots successfully. Plumb and Van Norman [a] do not regard their results as showing great value for roots, but think that they have an effect on the appetite, digestion, and general health that is beneficial, particularly in winter. In the Ontario [b] experiments the equivalent for 100 pounds of meal was 319 pounds of roots in the first and 564 pounds in the second. Day calls attention to the fact that both figures are very high values for roots, and points out that, "according to analyses and digestion experiments, there is approximately about nine times as much digestible matter in a mixture of corn and middlings as there is in mangels. It is difficult to explain, therefore, how 564 pounds of mangels should prove equal to 100 pounds of meal." The pigs receiving mangels showed the effects of their feed in more growth and thrift than the others. They had less tendency to become fat, and the root ration was reduced for this reason. Day [b] explains this effect of root feeding to be due to a "beneficial effect on the digestive organs of the animals, causing them to digest their food better than did the others; for there is little doubt that hogs closely confined in pens are likely to suffer from indigestion." Shaw [c] explains the marked effect of roots in similar

[a] Bul. No. 79, Indiana Expt. Sta.

[b] An. Rpt., 1901, Ontario Agricultural College.

[c] Bul. No. 27, Montana Expt. Sta.

words, stating that the value for sugar beets for pigs is "derived not so much from the nutrients in the dry matter which they contain as from the influence they exert on digestion and assimilation." This action of roots in the ration is undoubtedly similar to what has already been noted in the case of dairy by-products and pasture. The improvement that roots bring about in the condition of the digestive system must also affect indirectly the entire system and thus promote the general health.

Henry found the results at three American stations to be that about 615 pounds of roots saved 100 pounds of grain. The Danish experiments give 600 to 800 pounds of mangels and from 400 to 800 pounds of fodder beets as the feeding equivalent of 100 pounds of grain.[a]

The average of the results here given indicates that about 515 pounds of roots saved 100 pounds of meal, a somewhat higher value for roots than that given in previously published work.

An experiment conducted by Shaw[b] at the Montana Station, the results of which were published since the foregoing figures were compiled, showed an average daily gain for pigs of 1.58 pounds, at a cost of $4.60 per 100 pounds gain on grain only (9.11 pounds of grain per head daily); a second lot, on grain and sugar beets (6.65 pounds grain and 4.58 pounds sugar beets per head daily) made an average daily gain of 1.64 pounds, at a cost of $3.80 per 100 pounds. There were 4 pigs in each lot and they were fed 50 days. As a sidelight on the possibilities of pork production in the irrigated Northwest, it is interesting to note that Shaw found his net profit from feeding these 8 pigs to be $14.12, "or 33 per cent on the investment in fifty days."

Comparing various roots.—At the Central Experimental Farm in Canada, Grisdale[c] fed four lots of pigs to compare the feeding value of turnips, mangels, and sugar beets. In each case the meal mixture fed consisted of one-half corn, the other half being equal parts of oats, pease, and barley. In addition each pig was given 3 pounds of milk daily and all the roots he would consume. The roots were fed as follows: Lot I, turnips fed pulped; Lot II, mangels fed pulped; Lot III, sugar beets grown for forage, fed pulped; Lot IV, sugar beets grown for sugar production, fed pulped. The results were as follows:

Value of various roots for pigs.

Ration.	Number of pigs.	Average weight January 7.	Total gain.	Number of days fed.	Average daily gain.	Feed eaten.			Feed per 100 pounds gain.		
						Meal.	Roots.	Milk.	Meal.	Roots.	Milk.
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Lot I, turnips	4	101.25	363	106	0.85	780	3,808	1,284	215	1,049	354
Lot II, mangels	4	96.75	389	106	.90	786	5,930	1,284	202	1,524	330
Lot III, forage beets	4	76.75	500	106	1.18	793	4,298	1,284	159	860	257
Lot IV, sugar beets	4	57.00	[d]528	138	.95	1,032	4,266	1,680	195	808	318

[a] Feeds and Feeding, pp. 570, 571.
[b] Bul. No. 37.
[c] An. Rpt., 1901.
[d] Feeding ceased May 25.

On Lots I and II no deleterious results are mentioned in either buyers' or packers' reports. On Lot III the buyer reported 3 "select" and 1 "fat," and the packers' report was not so favorable to this lot as to Lots I and II. On Lot IV the buyer reported all "select;" there was no packer's report on carcasses of this lot.

In this experiment the pigs on forage beets made the greatest average daily gains and required the least feed for 100 pounds gain, the other lots standing in the order of sugar beets, mangels, and turnips. The results are remarkably low in feed requirements and would seem to show that roots and milk may be more advantageously combined than pasture and milk.

Day at Guelph and Shutt at Ottawa have found that the effect of roots on the carcass is not detrimental, but produces a firm bacon of good quality—a very essential matter to Canadian pig feeders. In this experiment neither buyers nor packers criticised adversely the pigs fed on turnips and mangels, and the carcasses of the sugar-beet pigs were all "select" (there was no packer's report on this lot); but the buyer found one carcass too fat in the lot fed on forage beets, and the packer's report was not so favorable as on the others.

Sugar beets alone.—At the Colorado Station, Buffum and Griffith[a] fed 4 pigs on sugar beets alone. There was some difficulty at first in inducing the pigs to eat beets, but after they had become accustomed to such a diet they took to it readily. At no time were the pigs able to eat beets enough to approach the conventional feeding standards; 12.50 pounds daily was the greatest amount they would take. For a brief period at the close (two weeks) forage beets were fed, the supply of sugar beets giving out. The results were as follows:

Average weight at beginning	pounds	100
Total gain	do	67
Days fed		99
Average daily gain	pound	.17
Average amount of feed eaten	do	1,027
Feed per 100 pounds gain	do	6,130
Cost per 100 pounds gain	dollars	12.30
Average profit with pork at 7 cents per pound	cent	.13
Dressed weight	per cent	77

Sugar beets alone are thus seen to be only a very expensive maintenance ration.

A comparison of sugar-beet pulp and sugar beets.—In Colorado, Buffum and Griffith[a] fed one lot of pigs on a ration of sugar-beet pulp and equal parts of wheat and barley; another on the same ration, except that sugar beets were fed instead of pulp; the results with a third lot, on equal parts of wheat and barley, are compiled in the table below as a check.

[a] Bul. No. 74.

The pulp cost, laid down at the college, $1 per ton. It was piled on well-drained ground and kept well without an undue amount of fermentation. The beets fed were grown on the college farm. Their cost was estimated at $4 per ton. During the last two weeks of the experiment the supply ran out and forage beets were substituted for sugar beets. The change is not thought to have influenced results.

There was some difficulty in inducing the pigs to eat the pulp, but the sugar beets were eaten from the start, although they were apparently not relished at first. The following table shows the results:

Sugar-beet pulp compared with sugar beets.

Ration.	Number of pigs.	Average weight at beginning.	Average gain.	Number of days fed.	Average daily gain.	Average amount feed eaten.			Feed per 100 pounds gain.			Cost per 100 pounds gain.	Average profit at 7 cents per pound.
						Grain.	Pulp.	Beets.	Grain.	Pulp.	Beets.		
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*	*Dolls.*
Grain	4	95	120	104	1.16	546.50	------	--------	450	------	------	4.50	3.90
Beet pulp and grain	4	97	88	99	.89	343	706	--------	390	800	------	4.30	3.35
Sugar beets and grain	4	101	98	104	.94	416	------	391	420	------	400	5.00	2.93

Potatoes.—Clinton[a] reports an unsuccessful attempt at Cornell to feed potatoes raw and cooked. Some grain and skim milk were given in addition, but, while over 400 pounds of potatoes were eaten, the pigs made no progress and were getting out of condition when the experiment was brought to a close. The low temperature while the pigs were being fed, ranging between 29° and 30° F., is suggested as a reason for the poor results.

At the Central Experimental Farm[b] very satisfactory results were obtained from cooked potatoes, but raw potatoes produced little gain. In one experiment the pigs were given all the raw potatoes they would eat, but made no gain and the tubers were discontinued. In a second test a similar experience led to a change to cooked potatoes. The opinion of investigators at this station is that raw potatoes are of little value for feeding pigs, but when cooked they are worth about one-fourth as much as mixed grain.

The following table shows the results of three tests where cooked potatoes were fed with success. The meal fed was a mixture of equal

[a] Bul. No. 199. Cornell University Expt. Sta.
[b] Bul. No. 33.

parts by weight of ground barley, ground rye, ground frozen wheat, and bran:

Cooked potatoes for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Average weight at close.	Average net gain.	Number of days fed.	Average daily gain.	Average amount feed eaten.			Feed per 100 pounds gain.		
							Meal.	Potatoes.	Milk.	Meal.	Potatoes.	Milk.
Potatoes (cooked), meal (soaked), skim milk	3	*Lbs.* 56	*Lbs.* 171	*Lbs.* 115	140	*Lbs.* 0.82	*Lbs.* 177	*Lbs.* 831	*Lbs.* 315	*Lbs.* 152	*Lbs.* 718	*Lbs.* 272
Potatoes (cooked), meal, skim milk	3	55	195	140	140	1.00	289	712	105	205	506	74
Potatoes (cooked), meal, skim milk	3	50	192	142	140	1.01	140	1,034	420	98	729	296

Sweet potatoes.—The Alabama, South Carolina, Maryland, and Florida stations have experimented with sweet potatoes with somewhat varying results.

At the Alabama Station, Duggar[a] fed one lot of pigs on a ration of three-fourths sweet potatoes and one-fourth ground cowpeas and another on a ration of equal parts of corn meal and cowpeas. After four weeks they were put through an intermediate period of one week and the rations were reversed, the lot that had formerly been on corn meal and cowpeas receiving the sweet potato ration. This was continued for four weeks longer, so that in all there were eight weeks' feeding on a sweet potato ration.

The ration of sweet potatoes and cowpeas proved very inferior to the ration of corn meal and cowpeas; the increase in live weight was nearly twice as great in the case of corn meal and cowpeas, and the dry matter per 100 pounds of gain was estimated at 600 pounds where sweet potatoes were fed to 360 pounds where corn meal was fed. Duggar refers to the difficulty of inducing the pigs to eat enough dry matter when sweet potatoes made up so much of the ration, and suggests a ration of equal parts of cowpeas and sweet potatoes as being more palatable and nutritious. He questions whether sweet potatoes can be profitably grown, stored, and fed to hogs unless the feeding value per bushel would be more than 10 or 15 cents. Where the pigs do the harvesting, especially on sandy soils, where the yield of sweet potatoes is ten or fifteen times that of corn, they may be an economical feed.

The results at the South Carolina Station were much more favorable to sweet potatoes. Newman and Pickett[b] fed a lot of 3 pigs, averaging 162 pounds in weight, on sweet potatoes only for forty-three days, beginning November 23. At the same time corn was fed to 3 pigs, averaging 156 pounds in weight. Two pigs in each lot were high-grade Berkshires and the third was a grade Duroc Jersey.

[a] Bul. No. 93. [b] Bul. No. 52.

Th pigs on sweet potatoes ate 26.2 pounds per head daily and made an average daily gain of 0.86 pound. They ate 3,247 pounds of sweet potatoes for 100 pounds of gain.

The pigs on corn ate an average of 9.2 pounds of grain daily, and made an average daily gain of 1.39 pounds, requiring 602 pounds of corn for 100 pounds of gain.

It was estimated that, at 200 bushels per acre, sweet potatoes would produce 369.5 pounds of pork per acre, worth $18.47 when pork is worth 5 cents per pound. The gain from corn was 139.5 pounds of pork, and the corn yield was 15 bushels per acre on land similar to that on which the sweet potatoes were grown. At 5 cents per pound for pork, the money return for the corn was $6.97 per acre.

The Maryland Station[a] reports an attempt to maintain pigs exclusively on sweet potatoes. A lot of rather mature pigs was put on a ration of small sweet potatoes and "strings" that were fed raw twice a day for thirty-one days. It required over 5 tons of these potatoes for 100 pounds of gain, and the return from them was only about $1.60 per ton.

The value of this feed when given with grain was tested with a younger lot of pigs for thirty days. With this lot, 593 pounds of sweet potatoes, 277 pounds of milk, and about 60 pounds of grain were required for 100 pounds of gain, and the value per ton of the potatoes was estimated at $2.40, showing sweet potatoes to be more valuable when fed with grain and milk.

The Florida Station[b] fed a lot of 4 native hogs on a ration of equal parts by weight of sweet potatoes and wheat middlings, the ration being 3.5 pounds of each per 100 pounds live weight of hog. They were confined in an open pen and fed twice daily. The hogs averaged 101.5 pounds at the beginning of the test and increased in weight 31.16 per cent, or 126.5 pounds, at a cost of 5.6 cents per pound of gain for feed eaten.

At the Alabama Station, Duggar[c] penned 2 shoats, averaging 116 pounds, on sweet potatoes for thirty-five days. They were given, in addition, 2 pounds of ground corn and 1 pound of ground cowpeas per head daily. In the time specified they gained 67 pounds, an average daily gain of 0.93 pound, thus requiring 313 pounds of grain in addition to the sweet potatoes for each 100 pounds gain. Duggar states that the sweet potatoes were not relished greatly and that there was much waste of them, due probably to the relatively large amount of grain fed.

Artichokes.—At the Oregon Station[d] French took 6 Berkshire pigs from wheat stubble on October 22 and placed them on a field of artichokes that had been planted in April on deep-plowed ground, prepared, as for potatoes, in rows 3 feet apart, with the seed 18 inches apart in the row. The growth was vigorous and the yield abundant, the tops growing to a height of 7 feet during the season,

[a] Bul. No. 63. [b] Bul. No. 55. [c] Bul. No. 122. [d] Bul. No. 54.

and a trial plot showing a yield of 740 bushels per acre. The pigs had free access to the field and did all the harvesting. An attempt to sustain them entirely on the tubers failing, some shorts were fed in addition.

At Ottawa, Grisdale[a] sowed a plot of one-sixteenth acre with about 70 pounds of tubers on May 19, planting in rows 24 inches apart, 4 inches deep, and 20 inches apart in the rows. Six pigs were turned in October 3. Although the tubers were immature at that time, the tops were from 10 to 13 feet high. The pigs were allowed a daily grain ration of 1.5 pounds of a mixture composed of one-half corn meal and one-half of a mixture of equal parts of ground oats, pease, and barley.

In both experiments the Jerusalem artichoke (*Helianthus tuberosus*) was used. The following table shows the results:

Artichokes as feed for pigs.

Station.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Grain fed.	Grain per 100 pounds gain.	Cost of grain per 100 pounds gain.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*	*Dollars.*
Oregon	6	162.6	244	50	0.81	756	309	1.85
Ottawa	6	104.6	197	21	1.57	189	96	1.80
Average							202.5	1.825

The cost of the meal in the Oregon experiment was estimated at $12 per ton; that in the Canadian one at $18 per ton. Valuing the meat made at $6.25 per 100 pounds, Grisdale estimates that, after deducting the cost of the meal fed, a balance of $10.61 is left for the artichokes fed, and deducting from this the cost of seed, planting, rent of land, etc., the one-sixteenth acre used gave a net return of pork worth $8.76.

ROUGHAGE.

Hogs are generally regarded as animals whose peculiar function is the conversion of concentrated feed into meat. Although the capacity for bulky feed that we find in the stomachs of cattle and sheep is lacking in hogs, a reasonable amount of bulk in the form of roots or hay is palatable and profitable. In many parts of the country, where concentrates are costly feeds, stockmen are forced to use substitutes for at least a part of the grain ration, both for fattening and maintenance, and over the entire country the winter ration is a problem. To solve these problems many western farmers have resorted to the use of alfalfa hay, and outside alfalfa districts clover hay is used. Considerable study has been devoted to this subject by the experiment stations.

Alfalfa hay.—The Kansas Experiment Station[b] has reported a series of experiments with drouth-resistant crops. Three of these

[a] An. Rpt. 1900, Central Experimental Farm. [b] Bul. No. 95.

experiments had to do with alfalfa hay. In the first, the hogs used were of mixed breeding—Berkshire and Poland China—representing about the average of Kansas farm hogs. The alfalfa was of good quality.

Two lots were fed—one receiving the hay whole in greater quantity than it would consume, the other having ground hay. In the second test the meal-fed lot received some cotton-seed meal—0.16 pound to each pound of Kafir corn, which did not affect the hogs seriously. This test was conducted during the most severe weather of the winter, the thermometer registering 32° F. below zero February 12, ten days after the experiment began.

In the third test the grain was wet with water at the time of feeding. The alfalfa hay had been cut late and was rather woody.

The Utah Station[a] fed one lot of hogs on a mixture of equal parts by weight of chopped wheat and bran, wet. Another lot had the same grain ration with chopped alfalfa hay added. "The alfalfa used was well cured and was prepared by running through an ensilage cutter, the blades of which are arranged for cutting into half-inch lengths." The pigs were thrifty grade Berkshires.

The Montana Station[b] fed three lots of hogs to compare the feeding values of a grain ration with sugar beets and alfalfa hay as roughage with a ration of grain only. The results of the lots that were fed on grain alone and on grain and alfalfa hay are presented herewith. The lot on grain alone received a ration consisting, during the early part of the experiment, of 2 parts of damaged wheat and 1 part oats, barley taking the place of the wheat during the latter part of the experiment. The hay-fed lot had the same ration with alfalfa hay added. The alfalfa hay was run through a cutting box, moistened, and mixed with meal. The hogs were by a Berkshire boar out of high-grade Poland China sows. They had previously had the run of a stubble field, with some clover pasture.

The following table shows the results of these experiments:

Value of roughage for pigs.

Ration.	No. of pigs.	Average weight at beginning.	Total gain.	No. of days fed.	Average daily gain.	Feed eaten.		Feed per 100 pounds gain.	
						Grain.	Hay.	Grain.	Hay.
Kansas:		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Kafir corn meal, dry	10	126	524	63	0.83	3,925	.....	749	.....
Kafir corn meal, dry, and whole alfalfa hay	10	127	909	63	1.44	4,679	659	515	72.4
Kafir corn meal, dry, and ground alfalfa hay	10	127	833	63	1.32	4,479	656	538	78.7
Kafir corn meal, and cotton-seed meal, wet	6	161	126	22	.95	681	.....	540	.....
Kafir corn meal, wet, and whole alfalfa hay	6	164	117	22	.88	629	251	538	214

[a] Bul. No. 70. [b] Bul. No. 27.

Value of roughage for pigs—Continued.

Ration.	No. of pigs.	Average weight at beginning.	Total gain.	No. of days fed.	Average daily gain.	Feed eaten.		Feed per 100 pounds gain.	
						Grain.	Hay.	Grain.	Hay.
Kansas—Continued.		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Kafir corn, whole	10	138	456	50	.91	2,910	.....	640	.....
Kafir corn meal	10	139	441	50	.88	2,872	.....	653	.....
Kafir corn, whole, and alfalfa hay	10	142	685	50	1.37	3,434	898	501	131
Kafir corn meal and alfalfa hay	10	140	686	50	1.37	3,535	844	516	123
Utah:									
Chopped wheat and bran	4	58	689	135	1.28	3,196	.....	464	.....
Chopped wheat and bran and chopped alfalfa hay	4	58	647	135	1.19	2,942	270	455	41.7
Montana:									
Grain only	7	111	557	66	1.20	2,967	.....	532	.....
Grain and alfalfa hay	7	111	552	66	1.19	2,683	370	486	67
Average:									
For lots fed grain only	.....	.....	.....	.....	.....	.....	.....	593	.....
For lots fed hay	.....	.....	.....	.....	.....	.....	.....	505	89

The feeding value of alfalfa hay, as indicated in the foregoing tables, does not in the least warrant a claim that it can be used economically as the sole ration. In all but two instances a considerable saving of feed was found to be effected by its use, but the statement that its feeding value is almost equal to that of corn is true only within certain limits. Where hogs are confined to an exclusive grain ration, and especially where this is made up of a single grain, the addition of a moderate amount of hay to the ration will be relished and less grain will be required. At the same time, better and cheaper gains are usually made by hogs so fed than by those on grain alone, but the value of the grain saved is out of all proportion to the value of the hay fed, and the hay in the ration can not be used economically in more than very moderate amounts. This is a similar fact to that which has been found by many investigators with such bulky feeds as green clover, rape, roots, and skim milk. That it is bad economy to attempt the maintenance of hogs on alfalfa hay alone is shown by the experiment noted below by McDowell in Nevada.

A consideration of the approximate proportions of hay to grain fed in these experiments is of interest. The greatest proportion of hay to grain was fed at the Kansas Station and the ratio was 1:2.5. With this ratio the least daily gain was made. The gains were the most expensive of any of the lots, and no advantage accrued from the use of hay. The least proportion of hay (1:11) was fed at Utah and gave the most economical gains. The greatest daily gain and the greatest amount of grain saved was in a Kansas lot fed whole alfalfa hay and

dry Kafir corn meal in the proportion of 1:7. The following table shows the effect of these rations in greater detail. The best results seem to come from the use of hay in the proportion of from one-seventh to one-fourth of the ration when hay makes up all the roughage:

Ratio of hay to grain in feeding hogs.

Ratio of hay to grain.	Average daily gain.	Feed per 100 pounds gain.		Grain saved.
		Grain.	Hay.	
Kansas:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1:2.5	0.88	538	214	1.8
1:4	1.37	501	131	139
1:4	1.37	516	123	137
1:7	1.44	515	72.4	234
1:7	1.32	538	78.7	211
Montana:				
1:7	1.19	486	67	46
Utah:				
1:11	1.19	455	41.7	9

Feeding alfalfa hay alone.—There is very little experimental work work on this phase of the subject. The opinions of experimenters and of stockmen generally seem to be that whenever hay alone is resorted to it is no better than a maintenance ration. In the alfalfa-growing districts hogs are frequently run through the winter at the haystacks owing to the scarcity and expense of a grain ration. At the Nevada Station, McDowell[a] fed two lots of 2 pigs each on a ration of alfalfa hay. The two lots ate in twenty-one days 99.12 pounds and 99.14 pounds, respectively, and lost in weight 33.25 pounds and 51 pounds, respectively, an average daily loss of 0.79 pound and 1.21 pounds, respectively. "While feeding hay alone the pigs spent much time curled up in the bedding, but when about the stalls were restless, and even in eating it was done in a ravenous way unlike that of a hearty, well-fed pig." After the hay-feeding period both lots were given grain and roots and made satisfactory gains.

Sugar beets compared with alfalfa hay.—The Utah Station[b] conducted three experiments, which give valuable data on the relative feeding value of sugar beets and alfalfa as winter roughage. In the first experiment Lot I had all the alfalfa hay they would eat and 2 pounds of corn meal per head daily. Lot II received all the beets they would eat and 2 pounds of bran per head daily.

In the second experiment Lot I had all the alfalfa hay they would eat and 2 pounds of bran per head daily; Lot II had all the alfalfa hay they would eat and 3 pounds of bran per head daily; Lot III had all the sugar beets they would eat and 2 pounds of bran per head

[a] Bul. No. 40. [b] Bul. No. 70.

daily; Lot IV had all the sugar beets they would eat and 3 pounds of bran per head daily.

In the third experiment Lot I had all the alfalfa hay they would eat and 2 pounds of a grain mixture of equal parts by weight of bran and chopped frozen wheat per head daily; Lot II was fed all the alfalfa hay they would eat and 3 pounds of the same grain mixture as Lot I per head daily; Lot III had all the sugar beets they would eat and the same grain ration as Lot I; Lot IV was fed all the sugar beets they would eat and the same grain ration as Lot II.

The Montana Station[a] fed one lot of 7 pigs on a grain ration consisting of 2 parts of damaged (frosted) wheat and 1 part oats, with raw sugar beets; another lot of 7 pigs had the same grain mixture, with chopped alfalfa hay. Barley replaced the wheat during the latter part of the experiment.

The following table combines the results of these experiments:

Alfalfa hay compared with sugar beets for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Total gain.	Number of days fed.	Average daily gain.	Feed eaten			Feed per 100 pounds gain		
						Grain.	Hay.	Beets.	Grain.	Hay.	Beets.
Utah:		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Alfalfa and corn meal	3	102	195	75	0.86	751	372	.....	385	191	.....
Sugar beets and bran	3	96	174	75	.77	[b]719	.....	1,109	414	.....	637
Alfalfa and 2 pounds bran per head daily	3	98	77	54	.47	315	242	.....	407	312	.....
Alfalfa and 3 pounds bran per head daily	3	102	85	54	.52	472	145	.....	553	170	.....
Sugar beets and 2 pounds bran per head daily	3	103	121	54	.75	315	.....	1,870	251	.....	1,541
Sugar beets and 3 pounds bran per head daily	3	102	155	54	.95	473	.....	1,270	305	.....	821
Alfalfa and 2 pounds grain per head daily	5	58	211	71	.59	700	388	.....	332	136	.....
Alfalfa and 3 pounds grain per head daily	5	61	292	71	.82	1,050	219	.....	359	75	.....
Sugar beets and 2 pounds grain per head daily	5	61	282	71	.79	700	.....	3,024	247	.....	1,072
Sugar beets and 3 pounds grain per head daily	4	92	301	71	1.06	1,050	.....	1,843	348	.....	611
Montana:											
Alfalfa and grain	7	111	552	66	1.19	2,683	370	.....	486	67	.....
Sugar beets and grain	7	114	576	66	1.26	2,497	.....	819	426	.....	142
Average, alfalfa									423	123	.....
Average, sugar beets									358	.....	617

[a] Bul. No. 27.

[b] Includes 235 pounds of corn meal.

This table shows an average for pigs fed on grain and alfalfa of 423 pounds of grain and 123 pounds of hay per 100 pounds of gain, and an average for pigs fed on grain and sugar beets of 358 pounds of grain and 617 pounds of beets—a difference of 65 pounds of grain, or over 15 per cent in favor of sugar beets.

Alfalfa hay and sugar beets in a grain ration.—Since the foregoing results were compiled the Colorado Station[a] has reported results unfavorable to either hay or sugar-beet feeding. Nine Berkshire pigs, averaging about 150 pounds, were fed. Lot I received a mixture of approximately 2 parts barley and 1 part corn, and about one-half pound alfalfa hay daily; Lot II had the grain ration only; Lot III had the grain ration and about 1 pound of sugar beets daily. There was some difficulty at first to get the pigs in Lot I to eat alfalfa, but when it was cut fine and mixed with barley slop they would take it. The results were as follows:

Alfalfa hay compared with sugar beets for pigs.

Ration.	Number of pigs.	Average weight at beginning.	Average gain.	Number of days fed.	Average daily gain.	Average amount feed eaten.				Feed per 100 pounds gain.			Cost per 100 pounds gain.	Average profit, pork at 5 cents per pound.
						Corn.	Barley.	Hay.	Beets.	Grain.	Hay.	Beets.		
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*	*Dolls.*
Grain and alfalfa hay	3	162	101	97	1.13	410	191	55	.....	544	49	.....	4.90	1.73
Grain only	3	155	105	97	1.08	381	174	.....	.....	528	.....	.....	4.60	1.94
Grain and sugar beets	3	148	96	97	.99	350	184	.....	99	555	.....	103	5.20	1.26

In this experiment neither the feeding of beets nor hay gave economical results. Grain feeding was cheaper than either, although the gains from grain and hay were somewhat larger than those from the pigs on grain only. The proportion of hay to grain fed in this experiment was approximately 1:11; that of beets to grain was a little wider than 1:5.

Corn fodder.—The Maryland Station has conducted a number of experiments with ground corn fodder, or "new corn product," as it is otherwise called. This product is the ground residue of cornstalks from which the pith has been removed. It was fed to pigs varying in age at the beginning from eight to twelve weeks. All rations contained milk, and the fodder was fed in different proportions to note any possibly advantageous results from such a practice. No special advantages could be observed from feeding the corn fodder, either in

[a] Bul. No. 74.

lessening the amount of grain required for 100 pounds of gain or in lowering the cost, except after the pigs were six months old. For fairly mature pigs the "new corn product" probably would have an effect in a ration somewhat similar to that of alfalfa hay.

BREED TESTS.

INFLUENCE OF BREED ON FEEDING POWERS.

In the foregoing pages attention has been called to the fact that there is very little difference in the standards of excellence for the various breeds of what has come to be designated the "lard," "fat," "block," or "corn-belt" hog. Tests of the different breeds made in different parts of the country show that, with standards that are similar to a large extent, there is very little difference in the cost of pork production by the best representatives of any of the established breeds. Indeed, these experiments show rather more, for they indicate that the breeds of the bacon type rank well in economy of gain with those of the "corn-belt" lard type. Curtiss and Craig[a] quote Hayward of the Pennsylvania Station to the effect that the results obtained in Maine, Massachusetts, and Ontario show the feed eaten per 100 pounds gain by various breeds to be as follows: Poland China, 407 pounds; Berkshire, 419 pounds; Tamworth, 420 pounds; Chester White, 500 pounds; Duroc Jersey, 522 pounds. The writer has averaged results for six leading breeds obtained by various experiment stations when there were a sufficient number of tests and a total number of pigs large enough to make the averages thoroughly representative. The stations whose figures were used are Maine, Vermont, New York State, Michigan, Wisconsin, and Iowa, in the United States, and the Ontario Agricultural College and the Central Experimental Farm, in Canada. The following table shows a variation in feed per 100 pounds of gain from 344 to 418 pounds:

Feed required for 100 pounds gain by different breeds.

Breed.	Number of tests.	Number of pigs.	Feed per 100 pounds gain.
			Pounds.
Tamworth	16	92	344
Chester White	13	71	347
Poland China	22	96	357
Berkshire	23	121	369
Large Yorkshire	11	67	407
Duroc Jersey	11	66	418

[a] Bul. No. 48, p. 444, Iowa Expt. Sta.

Iowa experiments.—Curtiss and Craig have reported the results of three years' feeding of purebred pigs of six leading breeds, including representatives of the Tamworth and Yorkshire breeds. While the pigs were with the dam, records were kept of all feed consumed and the loss or gain, and the loss or gain in weight of the sows was entered in the accounts of the total pork production before weaning. Henry reports the results of trials with 8 litters of pigs at the Wisconsin Station,[a] when he found the feed required for 100 pounds gain by both sows and pigs before weaning to be little more than that required by the pigs alone after weaning. In the Iowa tests there was a very marked variation in the maintenance of flesh by the sows, which was perhaps due rather more to individual than to breed differences, and which had much to do with the economy of the feeding before weaning. The average cost of 100 pounds of gain for the three years' experiments, both for the sows and pigs before the latter were weaned and for the pigs after weaning, was as follows:

Cost of 100 pounds of gain before and after weaning.[a]

Breed.	Sows and pigs before weaning.	Pigs after weaning.	Breed.	Sows and pigs before weaning.	Pigs after weaning.
Berkshire	$4.29	$2.33	Duroc Jersey	$5.61	$2.27
Poland China	3.15	2.23	Yorkshire	1.83	2.14
Chester White	3.27	2.46	Tamworth	2.22	2.42

[a] Bul. No. 48, Iowa Expt. Sta.

According to these figures, sows of the bacon breeds (Yorkshire and Tamworth) only made cheaper gains with their pigs before weaning than the pigs alone after weaning. The Poland China sows showed the cheapest gains among those of the lard, or fat, type.

After weaning the pigs, the Iowa Station[b] put on feed those that were in thrifty condition and compared the same breeds from this standpoint. The conditions of feed and management were as nearly alike as possible for each breed in each year's feeding. The nutritive ratio was 1:5.8 for all breeds in the first experiment, from 1:5.5 to 1:5.7 in the second, and from 1:7.1 in the third. The first year's work was nearly wrecked by hog cholera, so that the results of only a limited period of time were published. The following table has been arranged from the results, to show the feeding record of each breed in each experiment and the average of each breed for the three years' feeding.

[a] Feeds and Feeding, p. 541. [b] Bul. No. 48, Iowa Expt. Sta.

Breed tests of pigs—three years' experiments. [a]

Breed.	Number of pigs.	Average age at beginning.	Average weight at beginning.	Average weight at close.	Total gain.	Number of days fed	Average daily gain.	Dry matter consumed.	Dry matter per 100 pounds gain.	Cost per 100 pounds gain.
Berkshire:		*Days.*	*Lbs.*	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*
First experiment	10	59	26	90	631	92	0.68	2,959	462	3.01
Second experiment	10	43	31	192	1,588	153	1.03	6,056	381	2.17
Third experiment	10	65	43	214	1,717	164	1.04		481	2.23
Average							.98		441	2.33
Poland China:										
First experiment	5	63	40	107	334	92	.72	1,418	424	2.76
Second experiment	8	59	38	201	1,234	153	1.00	4,844	382	2.24
Third experiment	10	54	32	193	1,606	164	.97		441	2.12
Average							.90		419	2.23
Chester White:										
First experiment	10	59	33	103	689	92	.74	3,196	463	2.95
Second experiment	10	49	30	185	1,551	153	1.01	6,113	394	2.28
Third experiment	9	55	26	179	1,383	164	.93		506	2.41
Average							.89		454	2.46
Duroc Jersey:										
First experiment	10	58	34	115	828	92	.90	3,206	386	2.45
Second experiment	9	60	39	207	1,517	153	1.10	5,124	337	2.07
Third experiment	10	52	29	187	1,575	164	.95		506	2.36
Average							.98		410	2.27
Yorkshire:										
First experiment	6	69	35	109	447	92	.80	1,782	398	2.55
Second experiment	9	68	46	225	1,609	153	1.16	5,851	365	2.09
Third experiment	5	61	45	236	957	164	1.16		505	2.04
Average							1.04		423	2.14
Tamworth:										
First experiment	7	49	33	104	502	92	.77	2,028	403	2.62
Second experiment	10	60	52	210	1,539	153	1.00	6,266	407	2.31
Third experiment	8	75	52	221	1,354	164	1.03		558	2.47
Average							.93		456	2.42

[a] Bul. No. 48, Iowa Expt. Sta.

These figures show that the Yorkshires averaged highest in average daily gains, with the Berkshires and Duroc Jerseys tied for second place, and the Tamworth pigs next. In feed (digestible dry matter) required for 100 pounds gain, the Duroc Jerseys were first in least requirement, with the Poland Chinas next, the Yorkshires third, and the Tamworths last. In cost of 100 pounds gain the Yorkshires were first, the Poland Chinas second, the Duroc Jerseys third, and the Tamworths fifth. This evidence seems to disprove the charges sometimes made against the bacon breeds, namely, that these pigs make smaller and more expensive gains than those of other breeds.

Ontario experiments.—From the Ontario Agricultural College, Day has reported a number of experiments with six leading breeds. The pigs were fed for comparative purposes. At the close of each feeding period carcasses were examined for their suitability for the export trade, and reports were made thereon by the packers who killed the pigs. The following table shows the results of the feeding tests for five years, with the average of four:

Breed tests of pigs—five years' experiments.[a]

Breed.	Year of test.	Average weight at beginning.	Average weight at close.	Number of days fed.	Average daily gain.	Feed eaten.	Meal per 100 pounds gain.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*
Berkshire	1896	66	185	117	1.010	475	398.00
	1897	53	145	90	1.020	301	327.17
	1898	50	170	112	1.070	.....	369.79
	1899	.....	.....	.....	.....	.....	[b]318.28
	1900	.....	.....	.....	.803	.....	409.00
Average of 4 tests		.....	.....	.....	.978	.....	378.74
Poland China	1896	69	190	117	1.030	507	417.00
	1897	52	128	90	.840	253	332.89
	1898	69	187	112	1.050	.....	383.22
	1899	.....	.....	.....	.....	.....	[b]349.99
	1900	.....	.....	.....	.701	.....	474.00
Average of 4 tests		.....	.....	.....	.905	.....	401.78
Duroc Jersey	1896	62	199	117	1.160	580	424.00
	1897	65	149	90	.940	302	358.05
	1898	59	179	112	1.070	.....	376.04
	1899	.....	.....	.....	.....	.....	[b]337.10
	1900	.....	.....	.....	.883	.....	426.00
Average of 4 tests		.....	.....	.....	1.014	.....	396.02
Chester White	1896	62	185	117	1.050	557	452.00
	1897	52	127	90	.830	255	340.00
	1898	56	175	112	1.060	.....	377.77
	1899	.....	.....	.....	.....	.....	[b]336.68
	1900	.....	.....	.....	.666	.....	433.00
Average of 4 tests		.....	.....	.....	.902	.....	400.69
Yorkshire	1896	50	177	117	1.080	589	468.00
	1897	60	144	90	.930	285	340.62
	1898	52	176	112	1.100	.....	350.10
	1899	.....	.....	.....	.....	.....	[b]334.85
	1900	.....	.....	.....	.930	.....	422.00
Average of 4 tests		.....	.....	.....	1.010	.....	395.18
Tamworth	1896	54	171	117	1.000	469	400.00
	1897	52	139	90	.970	289	330.92
	1898	48	167	112	1.060	.....	377.77
	1899	.....	.....	.....	.....	.....	[b]331.16
	1900	.....	.....	.....	.642	.....	462.00
Average of 4 tests		.....	.....	.....	.918	.....	390.17

[a] An. Rpts., 1896-1900, Ontario Agricultural College. [b] Dry matter, not included in averages.

These figures show that the Duroc Jersey averaged first in average daily gains with 1.014 pounds, the other breeds following in this order: Yorkshire, Berkshire, Tamworth, Poland China, and Chester White. There is, however, very little difference between the Duroc Jersey, Yorkshire, and Berkshire in respect of average daily gains, and the Tamworth, Poland China, and Chester White form a second group, with average daily gains of slightly more than 0.90 pound. In the economy of gain the Berkshire stands first with 378.74 pounds as the amount of meal required for 100 pounds of gain, the other breeds following in this order: Tamworth, Yorkshire, Duroc Jersey, Chester White, and Poland China. In this respect the Berkshire is quite a little in the lead. The Yorkshire and Duroc Jersey form a group around 395 pounds and the Chester White and Poland China another group at 400 pounds. The Tamworth required 390.17 pounds meal for 100 pounds gain—somewhat less than the Yorkshire and Duroc Jersey.

Minnesota experiments.—At the Minnesota Station, Shaw[a] fed pigs of the Tamworth and Yorkshire breeds in comparison with Poland China. Like the Iowa trials, this was really a comparison of the feeding ability of pigs of the bacon type with those of the lard type. They were fed in pens 8 by 12 feet, with access to yards, but without pasture. The grain fed consisted of shorts, corn meal, and ground barley in varying proportions, and in the first experiment skim milk was fed. In both experiments green and succulent feed, such as pease, oats, corn, rape, and roots, was fed. During the first experiment one lot of Poland China pigs was on a ration that was mainly of corn meal, some shorts being fed in addition. The pigs in the first experiment were sold at $4 per 100 pounds and those of the second at $4.85 per 100 pounds. The following are the results for the purebred lots:

Breed tests of pigs—two experiments.

Breed.	Number of pigs.	Average weight at beginning.	Average gain.	Number of days fed.	Average daily gain.	Feed eaten.			Cost per 100 pounds gain.	Profit.
						Meal.	Milk.	Green feed.		
First experiment:		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dollars.*	*Dollars.*
Poland China	3	44	88	126	0.70	378	84	74	2.52	0.86
Poland China (corn-fed)	3	46	84	126	.67	398	44	143	2.31	.96
Tamworth	3	44	117	126	.93	418	44	144	2.01	1.89
Large Yorkshire	3	35	122	126	.97	419	53	161	2.02	2.07
Second experiment:										
Tamworth	3	51	119	126	.94	415	.....	252	2.32	2.68
Large Yorkshire	3	41	134	126	1.06	427	.....	252	2.11	3.40
Poland China	3	44	121	126	.96	454	.....	224	2.48	2.58

Wisconsin experiments.—The Wisconsin Station[b] tabulated the results of feeding for the different breeds and crosses used in an

[a] Bul. No. 73. [b] Eighteenth An. Rpt., p. 57.

experiment with pease and corn meal. The following table shows the averages:

Results of feeding pigs of various breeds and crosses.

Breeding.	Number of pigs.	Average amount of grain eaten daily.	Average daily gain.	Total gain per pig.	Feed per 100 pounds gain.	Cost per 100 pounds gain.	Internal fat.	Thickness of surface fat.
		Pounds.	*Pound.*	*Pounds.*	*Pounds.*	*Dollars.*	*Pounds.*	*Inches.*
Razorback-Poland China	2	4.27	0.985	166	433	4.957	13.35	2 705
Razorback-Berkshire	2	2.86	.57	119	505	5.772	9.52	2.32
Small Yorkshire	2	3.52	.875	148	400	4.556	9.67	2.21
Razorback	4	2.73	.52	110	547	6.227	10.378	1.99

Particular attention is called to the low gains of the Razorbacks, the large amount of feed they required for 100 pounds gain, and the large amount of internal fat.

In the Wisconsin[a] experiment to compare pease and middlings with corn meal the Berkshires made an average gain in one hundred and twenty-six days of 169 pounds—an average of 1.34 pounds daily for each pig. The Poland Chinas gained 153 pounds each—an average of 1.21 pounds each daily. The Yorkshires, leaving out of consideration a pig that fed poorly, made an average gain in one hundred and twenty-six days of 137 pounds—an average daily gain each of 1.08 pounds. The authors of the Wisconsin report state that this should not be regarded as a breed test.

These experiments, taken in connection with the evidence of investigators over the entire country, undoubtedly show that representative pigs of the different breeds do not differ materially either in the rate of gain or the economy with which the gains are made. Any marked differences in the breeds will be manifested in the suitability of the fattened animals for market and the quality of the carcass on the block. A very notable feature is the showing of the bacon breeds when compared with the lard breeds. The fact that a pig is a Yorkshire or a Tamworth can not be taken as prima facie evidence that it will make slow and expensive gains.

Value of different crosses.—At the Minnesota Station, Shaw[b] fed four lots of pigs to determine the relative value of Yorkshire pigs of first and second crosses. The pigs of the first cross were by a purebred Large Improved Yorkshire boar out of a high-grade Berkshire sow. Those of the second were sired by the same Yorkshire boar, out of a sow whose dam was the grade Berkshire that was the dam of the first litter and whose sire was a purebred Yorkshire. The four lots were therefore as nearly identical in breeding as possible without extreme inbreeding.

Lots I and III were first-cross pigs and Lots II and IV second cross. Lots I and II received a corn-and-oats diet and Lots III and IV a

[a] Seventeenth An. Rpt., p. 16. [b] Bul. No. 60.

barley-and-oats ration; and each lot had an 8 by 12 foot pen in a piggery, with a small paddock adjoining, where they ran for an hour or two daily.

The corn-and-oats ration was 1 part corn to 3 parts oats during the first period; during the second, 2:2; during the third, 3:1; and during the fourth, corn only. In the barley-and-oats rations barley substituted corn in the same proportion. Grain was ground, soaked twelve hours, and a little salt given at each feed. The pigs received all they would eat with relish. Some green feed, such as corn, second-growth clover, rape, and cabbage, was given.

Feeding tests of different crosses.

Breeding.	Number of pigs.	Age at beginning.	Total weight at beginning.	Total weight at close.	Total gain.	Number of days fed.	Average daily gain.	Grain feed eaten.	Green feed eaten.	Grain feed per 100 pounds gain.	Green feed per 100 pounds gain.	Cost per 100 pounds gain.
		Days.	*Lbs.*	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*
Lot I, first cross	3	108	247	601	354	112	1.05	1,394	322	393	111	1.65
Lot II, second cross	3	108	275	603	328	112	.98	1,483	297	452	90	1.89
Lot III, first cross	3	108	247	526	279	112	.83	1,178	267	422	95	1.83
Lot IV, second cross	3	108	279	567	288	112	.86	1,284	297	445	103	1.96

Other comparative results were as follows:

Average daily gain of first-cross	pound	0.94
Average daily gain of second-cross	do	.92
Cost of 100 pounds gain of first cross	dollars	1.74
Cost of 100 pounds gain of second cross	do	1.93

Comparing differing crosses.—Shaw[a] conducted two experiments to compare crosses of different breeds. The pigs were fed in 8 by 12 foot pens, with access to yards and lots adjoining for exercise, but no pasture. They were fed eighteen weeks. The feed was a mixture of shorts, corn, and barley, some green and succulent feed in season, such as peas, oats, rape, corn, and roots was given in each experiment, and all conditions were similar, except that during the first experiment the pigs had skim milk.

The pigs of the first experiment were sold at $4 per 100 pounds; those of the second, at $4.85 per 100 pounds.

The breeding was as follows:

First experiment:
Tamworth–Poland China cross.
Second cross, Large Improved Yorkshire on Berkshire.
Third cross, Large Improved Yorkshire on Berkshire.
Large Improved Yorkshire–Poland China cross.

[a] Bul. No. 73, Minnesota Expt. Sta.

Second experiment:
Third cross, Large Improved Yorkshire on Berkshire.
Large Improved Yorkshire–Poland China cross.
Tamworth–Poland China cross.
Large Improved Yorkshire–Poland China cross (Minnesota-bred dam).
Large Improved Yorkshire–Berkshire cross.

In the first experiment "The Tamworth–Poland China and Large Improved Yorkshire–Poland China crosses were obtained similar to those above described[a] and from a pure Tamworth and pure Large Improved Yorkshire sire, respectively. The second cross, or grade, of Yorkshire on Berkshire was from a dam the progeny of a Large Improved Yorkshire sire and a dam essentially Berkshire, but not registered. The third cross of Yorkshire on Berkshire was of breeding similar in kind, but once removed further from the original Berkshire dam."

In the second experiment there were some slight changes; the pigs of one Yorkshire–Poland China lot were out of a dam reared in the corn belt, while those of the other were out of a Minnesota-bred dam. "In several instances, however, the blood lines were not only the same, but the animals in the experiment were from the same sire and dam, as were those of the previous year." The results follow:

Feeding tests of crossbred pigs.

Breeding.	Number of pigs.	Average weight at beginning.	Average gain.	Number of days fed.	Average daily gain.	Feed eaten.			Cost per 100 pounds gain.	Profit.
						Grain.	Milk.	Green feed.		
First experiment:		*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Dolls.*	*Dolls.*
Tamworth-Poland China	2	47	118	126	0.94	456	83	80	2.24	1.61
Second cross, Yorkshire-Berkshire	3	56	131	126	1.04	499	72	108	2.17	1.84
Third cross, Yorkshire-Berkshire	3	33	104	126	.83	410	47	142	2.28	1.46
Yorkshire-Poland China	3	48	128	126	1.02	483	44	145	2.16	1.87
Second experiment:										
Third cross, Yorkshire-Berkshire	3	45	126	126	1.00	427	.....	252	2.25	2.98
Yorkshire-Poland China	2	63	166	126	1.32	577	.....	252	2.28	3.86
Tamworth-Poland China	3	48	147	126	1.17	482	.....	252	2.16	3.64
Yorkshire-Poland China (Minnesota-bred dam)	3	49	158	126	1.25	527	.....	252	2.18	3.89
Yorkshire-Berkshire	3	46	152	126	1.21	564	.....	196	2.43	3.38

Among Shaw's conclusions are the following remarks:

That the experiments do not sustain the view that the results will be less satisfactory from each succeeding cross of Yorkshire on Berkshire.

That the cross of Large Improved Yorkshire and Tamworth breeds upon the

[a] See experiments with crossbred swine, pp. 183, 184.

Poland China sows of the corn-reared types produces animals at once vigorous, shapely, of better growth, and relatively more profitable than pigs from the aforementioned sows.

INFLUENCE OF BREED ON THE CARCASS.

For the sake of convenience the term "slaughter test" is used in this bulletin to include everything from weighings on the floor of a packing house to a chemical analysis. Sufficient attention has not been paid to the effect of feed and conditions of management on the carcass, but the present drift of sentiment among workers in animal husbandry points to a more thorough study of the carcass in detail as a means of solving the problems that still confront the student and the feeder. No one can doubt that such investigations will have a high value when applied under feed-lot conditions.

At the close of the last two Iowa[a] experiments most of the hogs were shipped to Chicago and sold on the open market. In both experiments the different breeds had been fed on practically the same rations, and all conditions of feeding and management were similar; so that whatever differences might be found in the carcasses could very properly be ascribed to breed influence. In the packing house where the hogs were killed careful records were kept of the slaughtering, and elaborate reports made of these records. The following table has been arranged from these results. It shows the percentage of dressed weight of each breed and the total and average weights of the heads and viscera for each breed:

NOTES ON THE FOLLOWING TABLE.

NOTE.—The writer is under obligations to Swift & Co., Chicago, who killed the hogs, for the following explanation of terms used in these slaughter tests that are not self-explanatory:

Heads, gross.—The gross weight of the heads just as cut from the hogs, with tongues and lean meat in.

Heads, net.—The same heads trimmed for tank—tongues, cheek meat, and cheek-meat fat taken out.

Cheek meat.—Refers to the lean meat in the cheek of the hog. Scientifically expressed, includes masseter (*pterygoideus internus* and *externus*) muscles.

Cheek-meat fat.—The fat trimmed off in saving the lean meat.

Ham facings.—Refers to the facing of fat which is taken off the inside of the hams in order to give them a lean appearance and is taken off in all cases where American cut hams are made Where English long-cut hams are made this facing of fat is left on, accounting for the fact that in some of the tests ham facings are shown; in other tests they are not.

Plucks.—The liver, heart, and lungs comprise what is called the pluck. Total weight of the livers, hearts, and lungs added together should agree with the total weight of the plucks. Some differences in 1897 test, but weights balance approximately in 1898 test.

Bladders, gross.—The weight of the bladders as taken from the hogs filled, more or less, with urine.

Bladders, net.—Weight of the same bladders with the urine pressed out.

Gut fat.—Large intestines washed out.

Caul fat.—Omentum.

Ruffle fat.—Mesentery.

Bung guts, gross.—Floating colon and rectum combined is called the bung gut, and bung guts, gross, is weight before being cleaned.

Bung guts, net.—Same as above, but cleaned.

Paunches, gross.—Weight of stomachs as taken from the hogs.

Paunches, net.—Weight of stomachs cleaned.

Pig bags.—Refers to uteri.

[a] Bul. No. 48.

Slaughter tests of purebred hogs.

Breed.	Number of pigs.	Dressed meat.	Melts (spleen).	Heads.		Tongues.	Cheek meat.	Cheek-meat fat.	Leaf lard.	Kidneys.	Gullets.	Gullet fat.
				Gross.	Net.							
		Per cent.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Berkshire	10	76.20	3.00	105.00	85.00	8.00	10.00	2.00	40.00	3.00	12.00	0.50
	9	77.90	1.75	96.00	78.00	8.00	8.75	1.12	57.00	5.75	5.50	1.25
Average		77.04	.25	10.58	8.58	.84	.99	.16	5.11	.46	.92	.09
Tamworth	10	78.40	5.00	115.00	95.00	7.00	8.00	2.00	70.00	5.00	9.50	.50
	4	78.60	1.50	43.75	36.00	3.50	3.50	.75	15.00	3.00	2.50	.50
Average		78.46	.46	11.34	9.36	.75	.82	.20	6.07	.57	.86	.07
Chester White	9	78.40	4.00	98.00	75.00	5.00	6.00	2.00	55.00	3.00	9.50	.50
	8	77.80	1.50	78.75	65.00	5.75	6.50	1.50	45.00	4.50	5.25	1.75
Average		78.10	.32	10.40	8.24	.63	.74	.21	5.88	.44	.87	.13
Poland China	8	78.20	3.00	75.00	60.00	5.00	6.00	2.00	48.00	5.00	7.00	1.00
	9	79.00	2.50	84.25	70.00	6.00	7.00	1.25	48.00	5.00	6.00	1.50
Average		78.62	.32	9.37	7.65	.65	.77	.19	5.65	.59	.76	.15
Duroc Jersey	9	77.10	4.00	100.00	82.00	8.00	8.00	2.00	62.00	3.50	9.00	1.00
	9	77.00	2.12	86.00	70.00	6.25	7.25	2.25	41.00	5.00	6.50	3.50
Average		77.05	.34	10.34	8.45	.79	.85	.23	5.73	.48	.86	.25
Yorkshire	9	79.00	4.00	110.00	93.00	8.00	8.00	1.00	50.00	4.33	10.00	1.00
	4	79.60	1.25	42.25	35.00	3.25	3.25	.75	23.00	2.50	2.50	.50
Average		79.18	.40	11.71	9.85	.87	.87	.13	5.62	.53	.96	.11

Slaughter tests of purebred hogs—Continued.

Breed.	Ham facings.	Plucks.	Livers.	Hearts.	Lungs.	Bladders.	Bladders.		Bladder fat.	Total weight of guts.	Gut fat.	Caul and ruffle
							Gross.	Net.				
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Berkshire	4.00	64.00	32.00	6.00	15.00	.....	3.00	1.00	0.50	205.00	24.00	26.00
	.....	50.50	25.00	5.50	20.00	0.50	.....	.....	.....	218.00	31.00	32.50
Average	.....	6.03	3.00	.61	1.84	.....	.....	.....	.....	22.26	2.90	3.08
Tamworth	4.00	60.00	26.00	6.00	18.00	.....	3.00	1.00	.50	200.00	30.00	25.00
	.....	24.75	11.00	2.75	11.00	.50	.....	.....	.....	91.00	13.00	14.50
Average	.....	6.05	2.64	.63	2.70	.....	.....	.....	.....	20.80	3.07	2.82
Chester White	4.00	50.00	25.00	5.00	10.00	.....	2.00	1.00	.50	173.50	30.00	25.00
	.....	37.25	19.00	4.25	14.00	1.00	.....	.....	.....	156.00	29.00	24.00
Average	.....	5.13	2.59	.54	1.41	.....	.....	.....	.....	19.38	3.47	2.88
Poland China	4.00	50.00	27.00	5.00	10.00	.....	2.50	.50	.50	128.50	27.00	23.00
	10.50	44.25	27.00	4.75	12.50	1.00	.....	.....	.....	175.00	28.00	18.00
Average	.85	5.54	3.18	.57	1.32	.....	.....	.....	.....	17.85	3.24	2.41
Duroc Jersey	4.00	55.00	25.00	5.00	15.00	.....	2.00	.50	.50	189.00	25.00	29.00
	8.00	43.50	25.50	5.00	13.00	.75	.....	.....	.....	194.00	30.00	28.50
Average	.66	5.47	2.80	.56	1.56	.....	.....	.....	.....	21.28	3.05	3.20
Yorkshire	4.00	60.00	27.00	4.00	18.00	.....	4.00	1.00	.50	194.00	33.00	22.00
	.....	25.00	13.00	2.50	9.50	.50	.....	.....	.....	82.00	16.00	12.50
Average	.....	6.54	3.08	.50	2.12	.....	.....	.....	.....	21.23	3.77	2.65

Breed.	Bung guts.		Bung-gut fat.	Pig bags.	Small guts.		Stomachs.		Nutritive ratio.
	Gross.	Net.			Gross.	Net.	Gross.	Net.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	
Berkshire	7.00	5.00	10.00	3.00	40.00	25.00	15.00	12.00	1:5.6
	14.00	6.00	.....	2.25	34.00	19.00	21.00	14.00	1:7.1
Average	1.11	.58	.....	.28	3.90	2.32	1.90	1.37	
Tamworth	8.00	6.00	10.00	2.00	44.00	31.00	16.00	14.00	1:5.6
	7.50	3.00	.....	2.50	12.00	8.00	11.00	7.00	1:7.1
Average	1.11	.64	.....	.32	4.00	2.80	1.93	1.50	
Chester White	6.00	4.00	9.00	1.50	31.00	20.00	15.00	10.00	1:5.5
	10.00	4.00	.....	.75	25.00	15.00	15.00	11.00	1:7.1
Average	.98	.47	.....	.13	3.30	2.06	1.76	1.24	
Poland China	5.00	4.00	5.00	3.00	27.00	18.00	10.00	7.00	1:5.7
	15.00	5.00	.....	1.75	27.00	17.50	15.50	13.00	1:7.1
Average	1.18	.53	.....	.28	3.18	2.09	1.50	1.18	
Duroc Jersey	8.00	7.00	7.00	3.00	32.00	20.00	18.00	11.00	1:5.6
	14.75	6.75	.....	2.25	33.00	22.00	17.00	13.00	1:7.1
Average	1.27	.76	.....	.29	3.61	2.33	1.95	1.33	
Yorkshire	5.00	4.75	10.00	2.50	25.00	18.00	21.00	13.00	1:5.6
	7.00	3.00	.....	.50	14.00	8.00	7.00	6.00	1:7.1
Average	.92	.60	.....	.23	3.00	2.00	2.15	1.46	

The average of these tests shows the Yorkshire to be in the lead in dressed weight, the other breeds following in this order: Poland China, Tamworth, Chester White, Duroc Jersey, and Berkshire, the variation being from 79.18 per cent to 77.04 per cent.

Relative weights of vital organs.—The weight of vital organs is highly important. To ascertain what variations the Iowa[a] test showed in this respect the table below has been arranged. It shows the percentages of the weights of the vital organs to live weight for each breed in each experiment, with the average of both.

The average live weights of the hogs at the abattoir were as follows:

Average live weights of hogs of different breeds—Iowa experiments.

Breed.	1897.	1898.
	Lbs.	*Lbs.*
Berkshire	190	209
Tamworth	200	215
Chester White	177	181
Poland China	193	191
Duroc Jersey	202	180
Yorkshire	215	232

Relative weights of vital organs of purebred hogs.[a]

Breed.	Number of pigs.	Melts (spleen).	Tongues.	Kidneys.	Gullets.	Plucks.	Livers.	Hearts.
Berkshire:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Percent.*	*Percent.*
First experiment	10	0.16	0.42	0.16	0.63	3.37	1.68	0.32
Second experiment	9	.09	.43	.31	.29	2.68	1.38	.30
Average		.13	.42	.23	.46	3.03	1.50	.31
Tamworth:								
First experiment	10	.25	.35	.25	.48	3.00	1.30	.30
Second experiment	4	.18	.41	.35	.29	2.88	1.28	.32
Average		.23	.37	.28	.42	2.97	1.29	.31
Chester White:								
First experiment	9	.25	.32	.19	.60	3.14	1.57	.32
Second experiment	8	.10	.40	.31	.36	2.57	1.31	.29
Average		.18	.35	.25	.49	2.87	1.45	.30
Poland China:								
First experiment	8	.20	.33	.33	.46	3.24	1.75	.33
Second experiment	9	.15	.35	.29	.35	2.58	1.57	.28
Average		.17	.34	.31	.40	2.89	1.66	.30
Duroc Jersey:								
First experiment	9	.22	.44	.19	.50	3.02	1.38	.28
Second experiment	9	.13	.38	.31	.40	2.68	1.57	.31
Average		.18	.41	.25	.45	2.86	1.47	.29
Yorkshire:								
First experiment	9	.20	.41	.22	.52	3.10	1.40	.20
Second experiment	4	.13	.35	.27	.27	2.69	1.40	.27
Average		.18	.40	.24	.44	2.97	1.40	.23

[a] Bul. No. 48, Iowa Expt. Sta.

Relative weights of vital organs of purebred hogs—Continued.

Breed.	Lungs.	Bladders.	Bladders, net	Total weight of guts.	Bung guts, net.	Small guts, net.	Stomachs, net.
Berkshire:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
First experiment	0.79	.....	0.05	10.79	0.26	1.32	0.63
Second experiment	1.10	0.03	.....	11.99	.33	1.04	.77
Average	.92	.....	.....	11.19	.29	1.16	.69
Tamworth:							
First experiment	.90	.....	.05	10.00	.30	1.55	.70
Second experiment	1.28	.06	.....	10.58	.35	.93	.81
Average	1.01	.....	.....	10.19	.31	1.37	.74
Chester White:							
First experiment	.62	.....	.06	10.89	.25	1.25	.62
Second experiment	.97	.07	.....	10.77	.28	1.04	.76
Average	.79	.....	.....	10.83	.26	1.15	.69
Poland China:							
First experiment	.65	.....	.03	8.32	.26	1.17	.46
Second experiment	.73	.04	.....	10.17	.29	1.02	.75
Average	.69	.....	.....	9.30	.28	1.09	.61
Duroc Jersey:							
First experiment	.83	.....	.11	10.44	.39	1.10	.60
Second experiment	.80	.44	.....	11.98	.42	1.36	.80
Average	.82	.....	.....	11.14	.40	1.22	.70
Yorkshire:							
First experiment	.93	.....	.20	10.03	.25	.93	.67
Second experiment	1.03	.03	.....	8.84	.32	.86	.64
Average	.96	.....	.....	9.65	.27	.91	.66

In the relative amounts of spleen there are only two variations from a general average—the Tamworths, with 0.23 per cent, and the Berkshires, with 0.13 per cent.

In weight of kidneys the Poland Chinas lead, with 0.31 per cent, the Berkshires being lowest, with 0.23 per cent.

There does not appear to be any particularly constant influence due to breed or type in the relative weights of those vital organs that constitute the pluck. The combined weights of liver, heart, and lungs should approximate that under the head of pluck; if, therefore, there is any influence of breed on the development and weights of these organs we should expect to find evidences of it in uniform and constant differences in weights. In the weight of plucks the Berkshires lead in the average, with 3.03 per cent, the Tamworth, Yorkshire, Poland China, Chester White, and Duroc Jersey following in the order named, the lowest weight being 2.86 per cent of the live weight. Yet, in relative weights of the organs that are included in the pluck, the Berkshires are but once in the lead—in the weight of the heart, where less variation is seen than in the weights of livers and lungs, the

Yorkshire being the only breed that shows much variation from the general average. The variation in weights of livers and lungs is quite erratic. Poland Chinas lead in relative weight of livers, with 1.66 per cent, the other breeds following thus: Berkshire, Chester White, Duroc Jersey, Yorkshire, and Tamworth, the least amount being 1.28 per cent of the live weight. The Tamworths lead in relative weight of lungs, with 1.01 per cent, the other breeds following in this order: Yorkshire, Berkshire, Duroc Jersey, Chester White, and Poland China, the lowest weight being 0.69 per cent of the live weight.

We find some appearance of uniformity in the weights of stomach and intestines. The heading "Total weight of guts" includes, among others, the three items that follow it. The Berkshires lead in this respect, with 11.19 per cent, the breeds following thus: Duroc Jersey, Chester White, Tamworth, Yorkshire, and Poland China, the lowest weight being 9.3 per cent of the live weight. The Duroc Jerseys lead in net weight of bung guts, with 0.4 per cent, the breeds following in this order: Tamworth, Berkshire, Poland China, Yorkshire, and Chester White, the lowest weight being 0.26 per cent of the live weight. The Tamworths lead in net weight of small guts, the weight being 1.37 per cent; the other breeds stand thus: Duroc Jersey, Berkshire, Chester White, Poland China, and Yorkshire, the lowest weight being 0.91 per cent. In net weight of stomachs the Tamworths lead, the breeds following in this order: Duroc Jersey, Berkshire, Chester White, Yorkshire, and Poland China, the weights ranging from 0.74 per cent to 0.61 per cent of the live weight. The record of the Berkshires and Duroc Jerseys is seen to be fairly uniform. Definite conclusions can not be drawn from these figures and it may be questioned whether, in the light of the facts concerning the feeding possibilities of the different breeds on similar rations, the improved breeds will show any marked and uniform differences in the relative weights of the internal organs when fed on the same feed.

Lard yield of different breeds.—By common consent, the name "lard hog" has been applied by many people to that type of animal the development of which has very largely been brought about on American soil, in contradistinction from the "bacon" type of hog which has been brought to us from Great Britain and Canada.

The writer is under obligation to Swift & Co., Chicago, who killed the hogs used in the Iowa experiments, for the following information regarding the lard yield of the different breeds in the test of 1898. Concerning their figures, they say:

> We did not, on any of the tests made, tank the fats of each lot separately, the amounts being too small. However, we know approximately what these fats should yield in rendered lard, and we have attached herewith a statement showing the different test lots slaughtered by us during November, 1898, and what we estimate the fats, etc., should yield in lard.
>
> For your information we beg to say that the ham facings, heads, cheek-meat fat, gullet fat, gut fat, caul and ruffle fat, bones, tails, feet, and fat trimmings are,